province of nova scotia

DEPARTMENT OF MINES

groundwater section report 72-1

HYDROGEOLOGY OF THE TRURO AREA, NOVA SCOTIA

by

Terry W. Hennigar

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AND GEOLOGICAL SERVICES

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PREFACE

The Nova Scotia Department of Mines initiated in 1964 an extensive programme to evaluate the groundwater resources of the Province of Nova Scotia. This report on the hydrogeology of the Truro area forms part of this broader provincial programme.

The field work for this study commenced during the summer of 1965 when the Fraser Brook watershed was selected as the first representative basin for the study under the International Hydrological Decade programme in Nova Scotia. Detailed test drilling and mapping was carried out during the summer of 1967. The material for this report forms part of an M.Sc. thesis by Mr. T.W. Hennigar entitled Hydrogeology of the Salmon River and Adjacent Watersheds, Colchester County, Nova Scotia. The funding for this comprehensive project was a joint undertaking between the Canadian Department of Regional Economic Expansion (ARDA project No. 22042) and the Province of Nova Scotia. Use of the Dalhousie University's IBM/360-50 model computer was secured through the co-operation of the Department of Geology and was used in analysing some of the data contained in this report.

It should be pointed out that many individuals and other government agencies co-operated in supplying much valuable information and assistance throughout the period of study. To list a few: Mr. F.S.Shea, M.Sc., Director Mineral Resources and Geological Services and the staff on the Mineral Resources section, Nova Scotia Department of Mines, the Nova Scotia Research Foundation, and the Nova Scotia Agricultural College at Truro.

It is hoped that the information in this report will be useful for agricultural, municipal and individual water needs and that the report will serve as a guide for the future exploration, development, use and management of the important groundwater resources of the Truro area.

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Nova Scotia Department of Mines

Halifax, Nova Scotia
September, 1972

CONTENTS

APPENDICES

ILLUSTRATIONS

MAPS

TABLES

HYDROGEOLOGY OF THE TRURO AREA, NOVA SCOTIA

ABSTRACT

Large fresh water underground reservoirs are found in east-central Colchester County, Nova Scotia, in surficial Pleistocene deposits of sand and gravel and bedrock deposits of Triassic age. These underlie the area from Debert to Truro and adjacent areas to the north and east. It appears that individual screened wells with capacities up to two million gallons per day can be developed in the surficial deposits. Screened and gravel packed wells constructed in the Wolfville Formation should also yield up to about one million gallons per day. Wells drilled into all the other rocks can be counted on to produce at least enough water for domestic purposes. Because of the fracture type of permeability, these well yields may vary widely with location and depth. The only exception may be the soft Windsor shales which normally yield less than 1 gpm to wells.

However, adequate and suitable water supplies for domestic purposes can be obtained from wells in any area if consideration is given to the geology. Where drilled wells into the bedrock fail, a good supply can usually be found in the surficial materials.

Excellent quality water (both bacteriological and chemical) can be obtained from bedrock and surficial aquifers in the map area. However, in areas underlain by the Windsor Group, water with high total dissolved solids, primarily sulphate and calcium, is usually encountered. Also, wells drilled in the low lying areas bordering the Cobequid Bay may induce saltwater as a result of heavy pumping stresses. In other areas the two most common complaints of water quality is the presence of hardness and/or iron. In both cases these characteristics do not constitute a health hazard, but instead are noted as nuisances.

The generalized hydrological budgets determined for the Salmon River watershed between 1965 and 1969 indicate that of the average annual precipitation (320,000 acre-ft.), about 27 per cent is lost through evapotranspiration. Of the remainder, about 57 per cent appears as direct runoff, while 16 per cent occurs as base flow. Based on the annual water consumption of about 3,000 acre-ft. in the Salmon River watershed, the degree of utilization of groundwater (average annual supply about 50,000 acre-ft.) is in the order of about 6 per cent.

INTRODUCTION

Purpose and Scope of Investigation

With increasing population and industrial growth in the Truro area, the needs for more potable water will also be stressed. To date, relatively little is known about the potential of the groundwater resources and their optimum utilization in this area. More information is required by the Town of Truro, which has a mainly surface water supply source that is not entirely satisfactory.

The villages of Bible Hill and Salmon River which lie adjacent to the north and east boundaries, respectively, of Truro, are considered highly favourable growth areas. At present, their water supplies are obtained through privately owned individual domestic wells. The commerical businesses and industries in these villages likewise obtain their own water supplies from groundwater reservoirs. However, preliminary planning indicates that each of these villages will possibly construct a central water system. Therefore, information will be required on the hydrogeology to determine the feasibility of developing large capacity wells as a water supply for these areas.

Included in this report are discussions of:

1. the geology of the area.
2. an analysis of precipitation over the area.
3. the yields which can be expected from wells in the various geologic units.
4. the chemical quality of groundwater and the Salmon River.
5. river stage and groundwater level hydrographs.
6. the potential for developing irrigation, industrial, and municipal groundwater supplies.

General Description of the Area

Location, Access, and Extent of Area

The area under study, near Truro, Colchester County, is located in the northcentral part of the Province. Most of the area lies in a lowland at the head of Cobequid Bay, which is an easterly extension of the Minas Basin.

Geographically, the area is enclosed between 62° 54' and 63° 30' west longitude and 45° 15' and 45° 37' north latitude in the eastern portion of Colchester County, and covers about 550 square miles (Fig. 1).

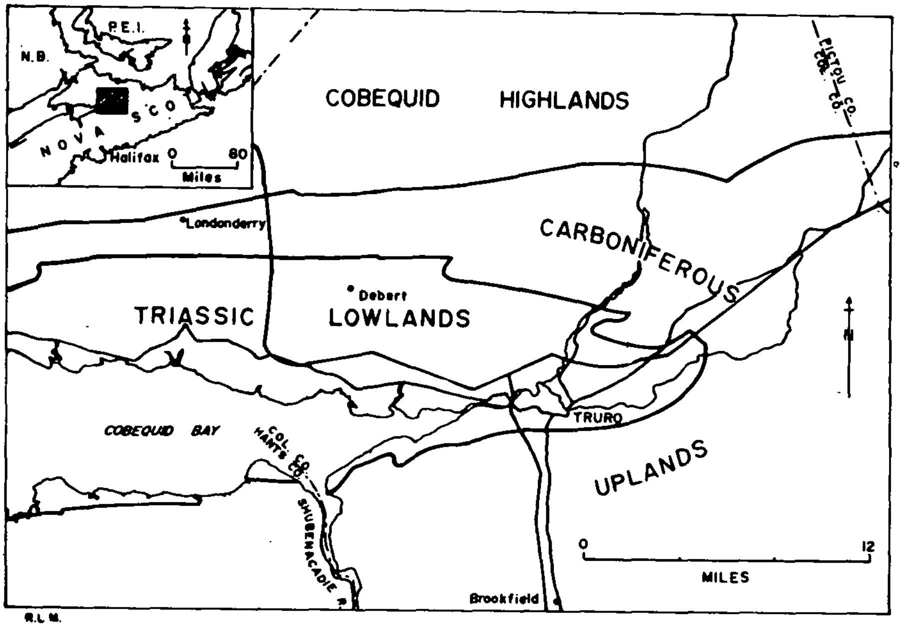


Figure 1. Location of the study area and its physiographic units.

Access from the south, Halifax to Truro, is available by Highway 102. To the west, the Trans-Canada Highway links the area with Parrsboro and Amherst, while Highway 4 provides a route north over the Cobequid mountains to the Northumberland shore. Eastward, the Trans-Canada Highway joins all that part of Nova Scotia and passes two miles north of Truro providing a route directly to Amherst. As of March 31, 1970, there were 339.6 miles of paved trunk and county highways in Colchester County and 770.1 miles were classed as graded and gravel surfaced. Total mileage amounted to 1109.7 miles (Nova Scotia Department of Development, 1970). Numerous secondary and unpaved roads, logging and other wood roads provide fairly good access to most parts of the map area.

The Town of Truro is also the hub and divisional point of the railroad system serving Nova Scotia, with the main line of the Canadian National

Railways entering Truro from the west. At Truro, the main line goes south to Halifax, and a branch line runs east to Sydney. The Dominion Atlantic Railway, a branch of the Canadian Pacific Railway, also links the Annapolis-Cornwallis Valley to Truro.

The nearest commercial airport is the Halifax International Airport, 39 miles south of Truro on Highway 102. Three smaller airfields serve the area; one military airstrip at Debert, 9 miles west of Truro; a public airfield at Trenton about 40 miles east of Truro; and a Nova Scotia Department of Lands and Forests airfield at Shubenacadie, 23 miles south of Truro on Highway 102.

Land Survey System

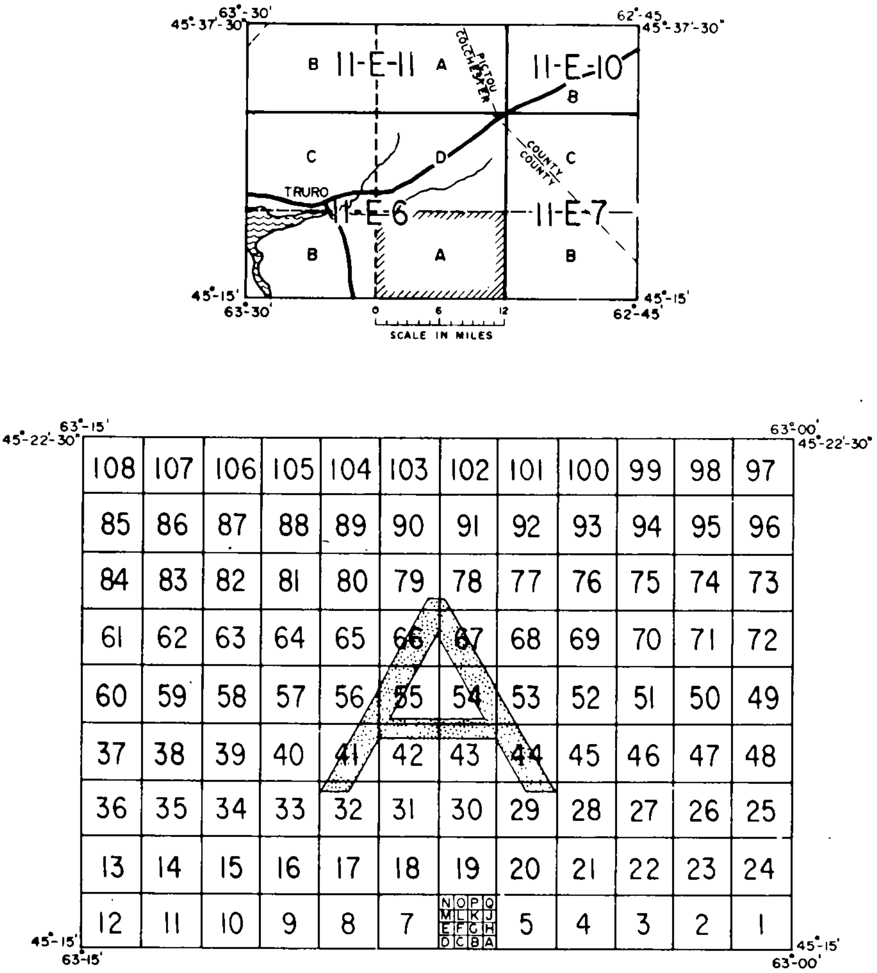
The National Topographical System which divides Canada into numbered primary quadrangles, each 4° latitude by 8° longitude, is used by the Nova Scotia Department of Mines for location of areas within the Province. The study area is included in primary quadrangle 11 (Fig. 2). This quadrangle is further divided into 16 larger scale maps such as 11E 6 on which the Town of Truro is located. This map (scale 1 : 50,000) is further divided into 4 parts, each containing 108 mining tracts of approximately 1 square mile each. Mining tracts are further subdivided with letters into 16 mining claims, each containing about 40 acres. Test holes, producing wells, and water samples cited in the text are located to the nearest mining claim.

Physiography and Drainage

The area under study contains parts of three physiographic units; the Cobequid highland, the Carboniferous upland and the Triassic lowland (Fig. 1), each of which is related to the underlying bedrock and structural geology.

Most of the area is an upland underlain by moderately resistant rocks Carboniferous in age. The northern and higher portion belongs to the Atlantic upland physiographic division of Nova Scotia (Goldthwait, 1924) here referred to as the Cobequid highland and is underlain by resistant rocks of Pre-Carboniferous age. The Triassic lowland, confined to the immediate area of Truro, and the Carboniferous upland together belong to the Hants-Colchester Lowland physiographic division outlined by Goldthwait (1924).

Most of the area lies within the Carboniferous upland which is underlain by sediments of the Horton, Windsor, Canso, Riversdale and Pictou Groups. These sediments include beds of conglomerate, sandstone, shale, limestone,



SOUTH HALF (REFERENCE MAP A) OF 1:50,000 MAP SHEET 11E6 EAST HALF SHOWING SUBDIVISION INTO 108 MINING TRACTS

MINING TRACT 6 DIVIDED INTO SIXTEEN 40 ACRE CLAIMS

Figure 2. National Topographical series showing Nova Scotia reference maps covering the area of study.

gypsum and anhydrite. The southern watershed boundary follows the Camden ridge, which trends northeasterly and is one of the highest features in this upland division. Elevations range from about 200 feet to a high of about 800 feet above sea level in the east portion of the area.

The head of Cobequid Bay marks the eastern limit of a syncline that extends from the Bay of Fundy to a point 5 miles east of Truro. Thus the area adjacent to the Town of Truro is underlain by sediments consisting of weakly consolidated conglomerate, sandstone, and shale beds of Triassic Age bordering the Cobequid Bay. These sediments reach a maximum altitude of about 400 feet where they terminate against the Horton sediments on the east, but generally the contact with Carboniferous sediments is at an altitude of approximately 200 to 300 feet. Onslow and Penny Mountains which lie north of Truro mark the contact between Triassic and Pennsylvanian, and Carboniferous sediments at altitudes of about 250 feet.

On the north the lowland is bounded by the Cobequid Mountain highland which is the surface water divide between the Northumberland Strait and the Cobequid Bay. The Cobequid Mountains form a flat-topped ridge from 8 to 10 miles wide stretching 75 miles across Cumberland County from the head of the Bay of Fundy almost to the Northumberland Strait. Broad rounded summits range in altitude from 850 to 1000 feet and blend to form a rolling surface with an average altitude over 900 feet.

These highlands consist mainly of crystalline rocks of granite, syenite, diabase and felsite which are more resistant to erosion than the weak, crumbling sandstone and shale beds of the surrounding lowlands. Infolded and enveloped are masses of contorted schists and slates of Silurian and Devonian age.

The study area includes watershed systems, mainly north and east of the Town of Truro, which contribute water to a common point on the Salmon River, just northwest of the town. During its course from the drainage area, where it is collected, to the Cobequid Bay, where it is discharged, the Salmon River, the principal drainage system, either flows through or underneath the Town of Truro (Fig. 3). The main tributary, the Black River, drains the eastern portion of the watershed and joins the Salmon River at a point between Union and Riversdale. The North River empties into Cobequid Bay north of Truro a short distance below the high tide mark of the estuary. In general, the North River with its headwater on top of the Cobequid Mountains flows from the north; the Salmon River (main branch) flows from the northeast where its headwaters originate in flows from the east where the high Carboniferous strata in that area contain the drainage divide. Three smaller streams, McCurdy Brook, McLure Brook, and Farnham Brook, have been segregated as distinct hydrologic units in order to determine their contribution to the total streamflow of the area. The measuring points selected on each stream are just above tidal effect of the Bay, which is the lowest point on the stream where fresh water may be withdrawn without the direct result of salt water contamination. The total drainage area of the watersheds shown in Figure 3 is about 270 square miles.

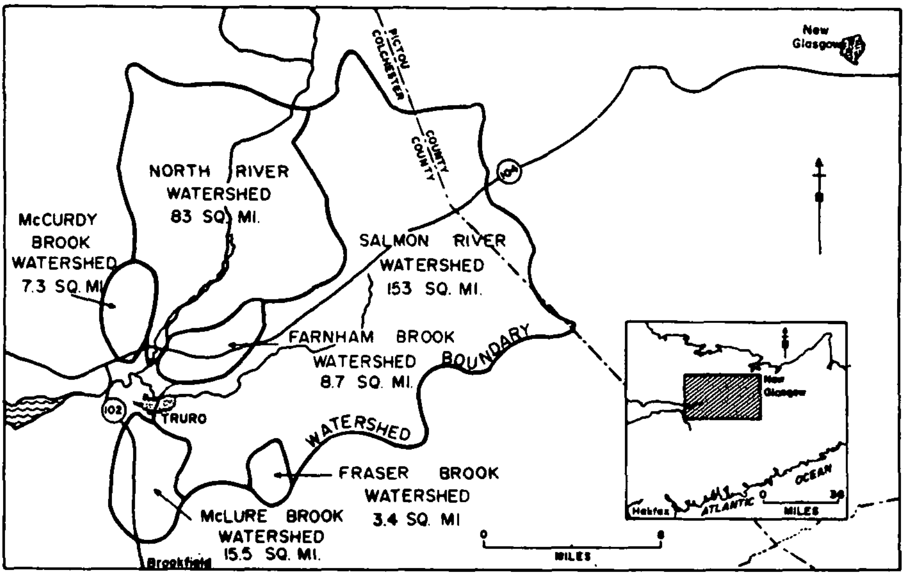


Figure 3. Watersheds within the immediate area of the Town of Truro.

Table 1. Drainage areas, drainage densities and stream profiles of watersheds in the immediate area of the Town of Truro.

Watershed	Drainage Area (sq. miles)	Drainage Density (miles/sq. mile)	Stream Profile Gross Slope (ft./mile)	Stream Profile Mean Slope (ft./mile)
Salmon River				
(a) Above Truro	152.7	1.42	35.7	21.7
(b) Above Murray	140.0	1.41		
North River	83.0	1.60	52.4	36.2
McLure Brook	15.5	1.72	59.4	37.1
Farnham Brook	8.7	1.20	54.0	38.0
McCurdy Brook	7.3	2.60	102.0	51.7
Fraser Brook	3.4	2.60	85.0	80.0

Table 1 summarizes data on the drainage areas, drainage densities, and stream profiles of six watersheds in the study area. Drainage area refers to the total area contributing to the runoff and sustaining part or all of the flow of the main stream and its tributaries (Dewiest, 1967) and is reported in square miles. Drainage density is the average length of streams per unit area within the basin and is reported in miles per square mile (mi./sq. mi.). A value for drainage density gives a comparative measure indicating the degree to which a watershed is drained. Dewiest, (1967), indicates that a basin with a drainage density of less than 1 mi./sq. mi. is poorly drained, whereas a drainage density of about 5 mi./sq. mi. indicates very good drainage. An examination of the data in Table 1 shows that the Farnham Brook watershed has the lowest drainage density and thus it is the poorest drained basin under study.

Two other observations from the data in Table 1 that should be noted are:

1. With the exception of the Farnham Brook watershed, as the drainage area increases, the drainage density generally decreases. Thus the small watersheds tend to be better drained than the larger basins.

2. As the drainage area decreases, the mean slope of the stream profile increases. This only applies to the mean slope, whereas the relationship between the drainage area and the gross slope appears to show no trend.

The Salmon River is evidently a consequent stream, but most of its tributaries are of the subsequent type and follow the less resistant beds of underlying bedrock (Stevenson, 1958). At several sites along their courses, the streams are superimposed upon glacial and alluvial deposits which conceal the underlying bedrock. A few local isolated areas underlain by Horton sediments, have a rectangular pattern which may reflect the presence of the numerous faults cutting the Horton rocks. In numerous instances these faults form the loci of local drainage gullies and control, in part, the channels of some of the larger streams (Stevenson, 1958).

Agricultural Soil Types

The types of farming practiced in an area are determined by the soils available; with the drainage, climate and native vegetation influencing the particular type of soil that forms. The most important factor influencing the type of soil in the study area is the parent material from which it is derived. The most abundant parent material in the area is glacial till which is an accumulation of unsorted earth material consisting of clay, silt, sand and gravel eroded and redeposited by glaciers. Two basic types of till are found in this area; clay till which covers almost 50 per cent of the area, and sandy till covering about 30 per cent of the area. The nature of these tills reflects the lithology of the underlying bedrock deposits from which they were derived. The second class of parent material comprises deposits of glaciofluvial sands, silts and gravels, which cover about 20 per cent of the area.

In Colchester County all the upland soils are classed as podzols. The soil profile of podzols contains highly leached materials which is typical of soils in Nova Scotia. Wicklund and Smith (1948) have classified the soils in associations which include groups of soils developed in the same kind of parent material. The soils that have been developed from the various parent materials and their suitability for agriculture are outlined in Table 2.

Table 2. Soils and their suitability for agriculture in the study area.

Parent Material	Soil	Land Use Capability	Use Restricted In Places By
Clay Till	Clay loam to gravelly sandy clay loam	Fair to poor crop land	Stone content and rough topography Drainage, fertility low pH
Sandy Till	Sandy to gravelly loam	Good to poor crop land	Stone content low pH
Glaciofluvial Deposits	Sandy to gravelly loam	Good to poor crop land	Subject to flooding low soil moisture capacity
Dykeland	Silty clay loam	Good crop land	Drainage subject to flooding

Soils resulting from the weathering of the surficial deposits (parent materials) in the area reflect the nature of the underlying bedrock. The surficial deposits have in turn been derived directly from the underlying bedrock and have not been moved very far. Therefore, a change in soil type can also indicate a corresponding change in the underlying surficial material and bedrock deposits. As a result, soil boundaries often correspond closely with boundaries marking a change in the type of underlying surficial deposits and bedrock contacts. While mapping the surficial deposits, the writer found that study of both the soil types and bedrock geology was most useful in determining the boundary between the sandy till and the clay till. Sandy till overlies the more granular strata of rocks belonging to the Fundy Group and the Pictou Group. Granular soils with generally very good drainage develop on this type of till. Clay till more commonly overlies the fine grained sediments of the Windsor Group, Riversdale Group and Canso Group.

Engineering Aspects of Soils

In civil engineering practice, soil means a natural aggregate of mineral grains, with or without organic constituents, that can be separated by gentle mechanical means such as agitation in water (Peck, Hanson and Thornburn, 1966). Rock is considered to be a natural aggregate of mineral grains connected by strong and permanent cohesive forces. In reality, however, there is no sharp distinction between rock and soil. Even the strongest and most rigid rocks may be weakened by the processes of weathering, and some intact rocks are as weak and compressible as soils (Peck, Hanson and Thornburn, 1966).

Soils are of interest to the civil engineer because engineering structures and projects depend on their characteristics and properties (such as shear resistance and/or hydraulic properties). These properties are important for highway construction, foundation engineering, the design of earth structures (stability of slopes and earth dams) and earth retaining structures (retaining walls and tunnels).

The accompanying Map 1 (Hydrogeology of the Truro area, scale 1 inch to 1 mile) should be of some value to engineers who may require a general idea of the earth materials with which to work in any given area. The deposits can be separated into three distinct categories:

1. Clay till, a compact and cohesive soil. In many cases it is free of boulders, but generally is composed of a mixture of sand and gravel with a high clay content.

2. Sandy till, a loose, sandy and/or gravelly material that in some areas has a fair amount of cohesiveness.

3. Glacio-fluvio deposits of silt, sand and gravel. These materials are very rarely cohesive and are composed of particles with a wide grain size distribution. However, individual stratum within these deposits may consist of very well sorted (or poorly graded) sand and/or gravel. These units also have very high hydraulic conductivities.

Population and Land Use

The population of Colchester County (DBS 1971) was 37,189 or about 5 per cent of the Nova Scotia total. The two main towns in the county, Stewiacke (population 1,003) and Truro (population 12,968) account for about 40 per cent of the total county population. The Nova Scotia Department of Trade and Industry (1964) shows that 17,396 (51 per cent) of the population in Colchester County is rural. The remaining 16,911 (49 per cent) of the population is classed as urban.

With a total land area of 1,451 square miles (930,000 acres), Colchester County ranks fourth in size in the Province and contained 1,168 cenus farms in 1961 according to the Dominion Bureau of Statistics. Most farming is mixed, with emphasis on vegetable production (cucumbers, carrots), tree fruit farming (apples and plums), small cultivated fruit farming (the leading crop is blueberries), field crops (tame hay, mixed grains). Dairy produce is also of major importance, the county ranks second in the province in numbers of livestock. The sale of lumber provides an added source of income for many of the farmers, although very little timber of marketable value remains except in the more inaccessible areas.

Of the 930,000 acres in the county, 259,013 acres, or 28 per cent of the total area, is classed as farm land; this includes 62,903 acres (6.8 per cent) of improved land. The Department of Trade and Industry (1964) show that of this 41,565 acres, 4.5 per cent are under crops, 18,322 acres are improved pasture, 235 acres (2 per cent) of summer fallow and 196,110 acres (21 per cent) as umimproved land.

In 1968, a forest inventory of the county classed 764,670 acres (85 per cent) as productive forest area. Forest production in 1970 indicates that the two main products are softwood and hardwood lumber and pulpwood.

Climate

The northern counties of the Province of Nova Scotia comprise a climatic region within the Maritime Provinces (Wicklund & Smith, 1948). This climate is described as a humid and temperate continental climate, modified by the Atlantic Ocean which almost completely surrounds the province, and the Gulf Stream which runs north easterly parallel to the Atlantic Coast. The proximity of the province to both the continental land mass and the Atlantic Coast tends to prevent extreme continental lows in the winter and high temperatures in summer.

The Province of Nova Scotia has been divided into five main climatic regions by Chapman and Brown (1966). The classification is based on temperature zones (based on degree days above 42° F and the frost-free period) and moisture classes (based on average water deficiency and average May-September precipitation. A summary of the regions and their climates is given in Table 3.

Table 3. Climatic regions for agriculture in Nova Scotia.

		Annapolis Valley	N. S. Interior (map area)	Cape Breton	North-umberland Shore	South Shore
	Degree Days Above 42°F	2950	2700	2500	2700	2800
	Potential Evapotranspiration (inches)	22	21	21	21.5	22
	Corn Heat Units	2200	1900	2000	2100	2100
Growing Season	Start End	April 20 Nov 2	April 22 Oct 31	April 30 Oct 30	April 27 Oct 28	April 30 Nov 5
Frost Season (32°F)	Spring Fall Period	May 24 Sept 30 130	May 28 Sept 25 120	May 30 Sept 25 115	May 25 Sept 30 130	May 20 Sept 30 130
Mean Temperature °F	Annual Min. January July	-10 22 66	-15 21 65	-10 20 64	-15 18 65	-5 25 62
Precipitation (inches)	Deficiency May - Sept Annual	0.5 16 41	0 17.5 48	0 19 50	0.5 19 38	0 >20 55

**Summarized from Chapman and Brown (1966).*

Precipitation in central Nova Scotia varies significantly as is shown in the chapter on hydrology, but the mean temperatures are much less variable. Truro has a mean annual precipitation of 11.0 inches less than Halifax (60 miles south).

Measurements at the Truro meterological station have been determined from over 30 years of continuous records. The mean annual precipitation at Truro is 41.7 inches; this consists of 34.9 inches as rain and 67.9 inches snow. The maximum mean monthly precipitation (4.6 inches) occurs in the month of November, 4.3 inches of this occurring as rain. The minimum mean monthly precipitation (2.8 inches) occurs during the month of June. The maximum precipitation in a 24 hour period (1931-1958) was 4.6 inches (September, 1942). The mean monthly snowfall 18.1 inches occurs during the month of February.

The mean annual temperature recorded in Truro is 42.8°F. The minimum mean monthly temperature is 20.9° F for the month of February, whereas July has the maximum mean monthly temperature 64.8° F.

The length of the frost-free period in Colchester County ranges from 100 to 120 days, being slightly longer in the northern part of the county. The length of the growing season ranges from 180-190 days (Wicklund & Smith, 1948). A late spring is attributed to prevailing northeasterly winds and frequent precipitation which often delays seeding operations until June.

Previous Investigations

The earliest scientific description of the rocks of Nova Scotia is found in a paper presented to the "American Journal of Science" by Messrs. Jackson and Alger in 1826 (Stevenson, 1958), in which they refer to gypsum beds outcropping on the Shubenacadie River.

In 1836, Dr. Abraham Gesnor produced "Geology and Minerology of Nova Scotia", the first comprehensive study of the rock types of the formations and mineral occurrences in Nova Scotia, in which he attempted to classify the different rock types of the Province by districts. He later published "The Industrial Resources of Nova Scotia" in 1849.

In his book "Travels in North America", Sir Charles Lyell (1843) described his observations on the geology of Nova Scotia, based on his visit to the area in 1842. Sir William Dawson in his four editions of "Acadian Geology" (1855, 1868, 1878, 1891) established the foundation of Carboniferous stratigraphy in Nova Scotia. He made a comprehensive description of the Windsor sediments along the Shubenacadie River and was the first to assign a Triassic age to the unfossiliferous, limy sandstone beds of the area.

The first detailed geological mapping with emphasis on mineral showings of the area was carried out by Hugh Fletcher (1887-1891).

Dawson (1893) described some of the glacial features of Nova Scotia, and Daley (1901) dealt in a general manner with the physiography of the Province. The latest publication dealing with the physiography, geomorphology and effects of glaciation in Nova Scotia is the "Physiography of Nova Scotia" by Goldthwait (1924). Powers (1916) in a report on the "Acadian Triassic" deals mainly with the Triassic rocks in western Nova Scotia and southern New Brunswick and briefly discussed these sediments in the Truro area.

In 1927, Dr. W. A. Bell published the first comprehensive report on the Carboniferous stratigraphy of Nova Scotia. L. J. Weeks (1948) in his report on the Londonderry and Bass River map areas, established a type sequence for the carboniferous rocks in that area, which lie immediately to the west of 11E 6 Truro map area.

The geology of the Truro map sheet was mapped in detail by I. M. Stevenson (1958). This report deals with all known deposits of economic interest within the area, and additional results of this work shed new light upon the origin, structure, and age relations of many of the geological formations.

Previous to this investigation little work on the hydrogeology of the watersheds had been carried out. Although meterological records have been collected at Truro and several other sites in the area for the past 30 years, data on the other phases of the hydrologic cycle were not available. In August, 1964, the Water Survey of Canada, Inland Waters Branch, Department of Energy, Mines and Resources, installed a water level recorder on the Salmon River at Murray, to provide a continuous record of stream flow. In the autumn of 1965, the Water Survey of Canada also erected a composite weir and installed a water level recorder at Fraser Brook to measure stream flow. In addition, the Meterological Branch of the Department of Transport installed a network of various meterological instruments in the watershed.

A groundwater probability map of Truro Map Sheet (west half) (Brandon, 1966, indicated in a preliminary way the probable quality and quantity of water to be expected from wells drilled into the various geological units of the area.

Some mapping of Colchester County (sponsored by the Nova Scotia Research Foundation) has been done by Professor R. H. MacNeill and his students at Acadia University, the results of which are being prepared for publication. The "Soil Survey of Colchester County" by R. E. Wicklund and G. R. Smith (1948), provides an outline of the distribution and extent of various surficial geologic deposits. Hennigar (1968) briefly described the geology and groundwater resources of the Salmon River and adjacent watersheds.

Various reports have been written on the occurrence of economic minerals and the results of core drilling in the map area. These reports and drilling records are available for study at the Technical Records Library, N. S. Department of Mines in Halifax.

Field Work and Maps

Field work began in the area during the summer of 1965 when the Fraser Brook watershed was selected as the first representative basin for study under the International Hydrologic Decade Programme in Nova Scotia. During the same summer, water samples were collected from wells in various parts of Colchester County and a water level recorder was installed in a well drilled into the Triassic sediments at Bible Hill.

Mapping in the field was aided by soil reports, maps, air photos (flown in 1954 and 1959) and well drillers' logs. The distribution of the surficial deposits was determined largely from field investigation and were mapped on a scale of 1 : 50,000. However, in the unaccessible areas, contacts between surficial units were determined by air photo interpretation of the deposits, using mainly drainage, land forms and topography as guides.

A test drilling programme to determine the thickness and character of the surficial deposits of the area was carried out during the summers of 1966 and 1967. Pumping test data were analysed from test wells developed in the surficial and Triassic aquifers. Water level recorders were installed in three wells drilled into the Salmon River flood plain at Murray Siding. During the summer of 1967, a precipitation gauge network was established throughout the Salmon River watershed, and surface water samples were collected to compare the water chemistry of the Salmon River with river stage.

Preliminary depths of surficial deposits were determined by running profiles with a hammer seismograph owned and operated by the Nova Scotia Research Foundation. A power auger also belonging to the Foundation was utilized in mapping the surficial deposits of the area and in drilling test holes to be used as observation wells during pumping tests.

All chemical water analyses were done by the Provincial Laboratory at the Nova Scotia Agricultural College under head chemist G. Byers. Bacterial examination of the samples collected from the Salmon River were carried out by the Pathology Laboratory at the Colchester County Hospital.

Acknowledgments

This investigation under the direction of John F. Jones, Chief, Groundwater Section, Nova Scotia Department of Mines, was jointly sponsored by the Canada Department of Forestry and Rural Development (under authority of the Agricultural and Rural Development Act) and the province of Nova Scotia. Recently the administration of ARDA was transferred to the Canada Department of Regional Economic Expansion.

Yucel Turker and David Urquhart provided very able assistance in the field. Professor R. H. MacNeil, Acadia University, provided valuable assistance and information on the surficial geology of the area and was instrumental in supplying data allowing completion of the surficial map of the area. The gathering of basic data was facilitated by the cooperation of the water well drillers who operate in the area, and by many of the residents whose interest and assistance was greatly appreciated. The prepared maps and illustrations in this report have been drafted by D. Bernasconi and his staff of the Cartographic Section, Geological Division, Nova Scotia Department of Mines.

GEOLOGY

Introduction

This section of the report provides background information on the geology of the study area. The discussion of hydrostratigraphic units in the following section is based on the description of the various geological units which can be categorized basically as rock units and surficial deposits. Included are descriptions of the areal distribution, lithology, structural relations and age of the various units (Table 4). The rock units include metamorphic rocks of pre-carboniferous age (Silurian), granitic intrusions of Devonian age, and a variety of sediments Mississippian, Pennsylvanian and Triassic in age (Figure 5).

Carboniferous sediments of the area were deposited in the Minas sub-basin (Bell, 1958) which is part of the larger Fundy geosynclinal area. This sub-basin lies south of the Cobequid highland and north of an upland in southern Nova Scotia and extends from Minas Channel east to the Stellarton structural gap. Carboniferous strata in the Minas sub-basin range in age from early Mississippian (Horton sediments) to late Pennsylvanian (Pictou sediments). They are conformably overlain in the Minas Basin area by non-marine late Triassic red sediments.

The surficial deposits consist of glacial till and glaciofluvial deposits of pleistocene age and recent alluvial deposits along the lowland of the major streams (map 1). The thickness of these deposits vary from only a few feet on the uplands where the till cover is generally very thin, to about 130 feet over the Triassic Lowlands.

Rock Units

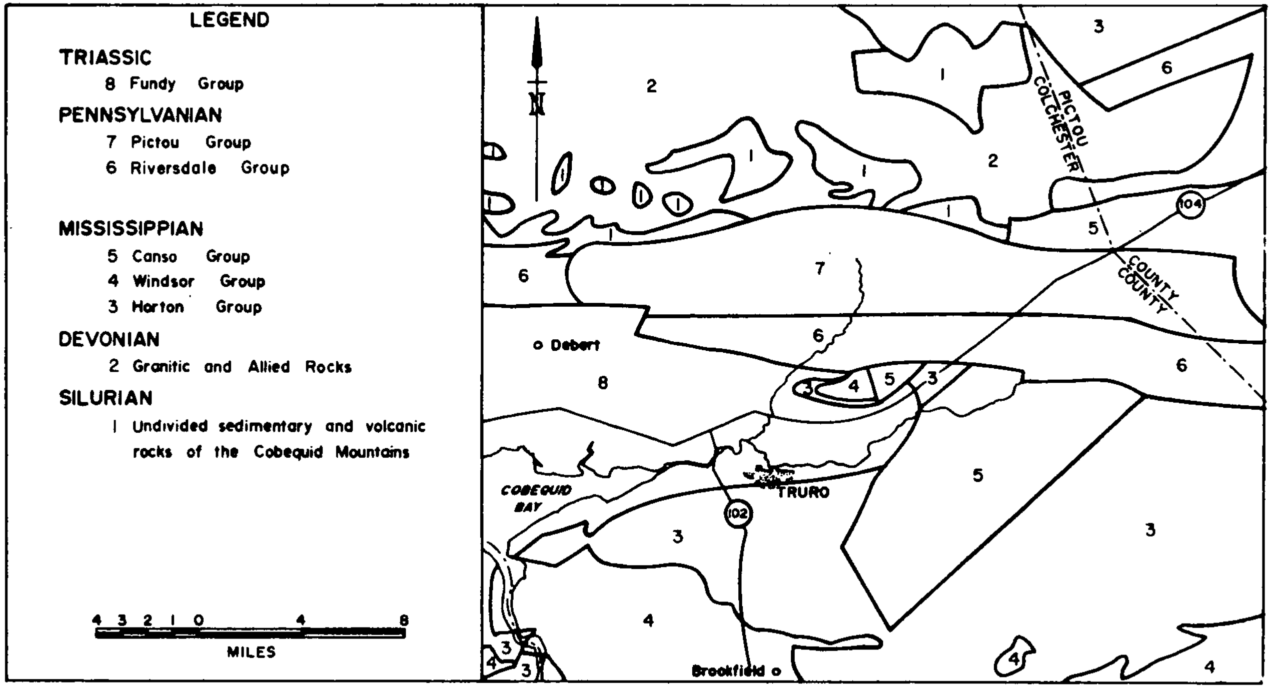
Cobequid Complex

The Cobequid complex consists of a series of sedimentary and volcanic rocks that have been intruded by syenite, granite, diabase, and felsite rocks of Silurian and Devonian ages (Stevenson, 1958). These rocks may be divided into two distinct lithological groups. The older group consists of a series of mixed sedimentary and volcanic rocks whose age relationships are uncertain but lie south of the main igneous granitic mass or core. Cutting these rocks is a series of younger intrusive rocks that range in composition from diabase to granite.

Table 4. Table of formations.

Era	Period or Epoch	Group or Formation (approx. thickness, feet)	Lithology
Cenozoic	Recent	0 - 8'	Stream alluvium, tidal flats, salt & marsh; dykeland
	Pleistocene	0 - 130+	Glacial drift, stratified sand and gravel estuarine deposits
		Unconformity	
Mezozoic	Triassic	Fundy Group Wolfville Formation 1,000	Brick-red, calcareous sandstone, conglomerate,
	Unconformity and Basic Intrusions?		
Palaeozoic	Pennsylvanian	Pictou and Cumberland groups 6,500	Brown, green, and grey conglomerate, sandstone, shale
		Riversdale Group 7,000	Grey shale, sandstone
		Unconformity (?)	
	Mississippian	Canso Group (Unknown)	Red and grey sandstone shale
		Disconformity (?)	
		Windsor Group (Upper) 1,300	Grey limestone, red and green shale, gypsum (?)
		Windsor Group (Lower) 1,300	Black and red limestone, red and green shale, gypsum
		Pembroke Formation 100	Red limestone, conglomerate red calcareous shale
		Macumber Formation 30	Grey, arenaceous, laminated limestone
		Minor Disconformity	
		Horton Group 4,000	Red and grey, sandstone, grit, shale, conglomerate
	Devonian ?		Granite, syenite felsite, diorite, acidic porphyritic rocks, aplite dykes, diabase
	Pre-Carboniferous		Argillite, shale, sandstone, chloritic schists, graphitic schist

* Modified with a few additions from Stevenson (1958), Weeks (1948), Bell (1958).



R.L.M.

Figure 4. Bedrock geology of the study area (adapted from the Geological Map of Nova Scotia, Weeks, 1965).

The main sedimentary rock types in the complex consist of fine-grained, purplish argillites, red and grey sandy shales, and green, grey and brown sandstones. These various rock types have been subjected to severe shearing movements with accompanying recrystallization under pressure which lead to the formation of chloritic and graphitic schists.

The main body of intrusive granitic rocks forming the core of the mountains is confined to the extreme northern part of the map area. The rocks have suffered intensely from fault movements that occurred along the southern face of the Cobequid Mountains. The more basic intrusive rocks extend farther south into the pre-Carboniferous sedimentary rocks. These intrusive rocks include minor amounts of granite, porphyritic rhyolite and aplite dykes in diorite and diabase dykes. The main batholitic intrusive of Cobequid Mountains may be tentatively ascribed a Devonian age (Weeks, 1948), while the minor intrusive may be either Devonian or Carboniferous in age. Diabasic dykes on the Salmon River are post-Mississippian and probably pre-Triassic in age because nowhere in the area are intrusions found in the Triassic sediments (Stevenson, 1958).

Horton Group

The Horton Group rocks are Mississippian age and in Nova Scotia are the oldest rocks of the Carboniferous group. They are overlain by the Windsor Group in apparent structural conformity. Horton strata outcrop in the southern part of the map area and are best exposed along Lepper Brook at Truro. These strata consist of a sequence of conglomerate, grit, sandstone, siltstone, and shale beds. The boundary between the Horton rocks and the overlying younger Triassic sediments is exposed in a number of places to a point about a mile west of Christie Brook (5 miles east of Truro) where Horton rocks are faulted against the Canso Group of sediments. Bell (1929) divided the Horton Group into the Horton Bluff and Cheverie Formations. The lower or Horton Bluff Formation consists of grey, feldspathic conglomerates, grits, and sandstones, interbedded with dark grey argillaceous shales. The upper or Cheverie Formation consists chiefly of red shale and grey arkosic grits. However, because of lithologic similarities, lack of completely exposed section and structural complexities, the Cheverie and Horton Bluff formation cannot everywhere be separated in the Truro map - area (Stevenson, 1958).

The presence of crossbedding and current ripple-marks, channelling, lenses of sandstones and conglomerates (lenticular strata), rain prints and broken up plant remains, erect plant stems and sun cracks indicate a fluviatile or terrestial environment of deposition. A statistical study of the current ripple-marks indicates the dominance of northeasterly flowing currents (Stevenson, 1958).

The mineralogical composition of the Horton sedimentary rocks offer conclusive proof that they were formed from the Devonian granite batholith and associated Precambrian rocks that lie to the south.

Horton rocks in the area are folded and cut by numerous faults with small stratigraphic displacement.

Windsor Group

A small area about 4 miles northeast of Truro is underlain by undifferentiated marine sedimentary rocks of Windsor age (Mississippian) that conformably overlie Horton sediments. The main body of Windsor sediments, however, lies in the southwest portion of Truro map sheet. These sediments consist of red and green sandy shales, limestone, minor dolomite, anhydrite, gypsum and salt.

The Windsor Group in the study area has been subdivided into lower and upper parts. The lower part contains three basic formational units: the Macumber Formation, consisting of grey sandy laminated limestone; the Pembroke Formation, of red limestone, conglomerate and red shales; and late Lower Windsor rocks consisting of red and green shales, marine limestone, and gypsum and anhydrite. The upper part of the Windsor Group consists of grey limestone, red and green shales and possible gypsum.

Canso Group

Upper Mississippian terrestrial sedimentary rocks of the Canso Group underlie the south-central and northeast portions of the map area. These sediments were probably derived in part from an older upland that lay to the south during late Mississippian time and from the Cobequid Highlands in the north. They were deposited in a fluvio-lacustrine environment and consist of sandstones which are interlayered with bands of fissile, chocolate-red shale showing ripple marks, cross bedding, laminations and mud cracks. Stevenson (1958) indicates that narrow bands of conglomerate are present, and quartzites interlayered with massive maroon shales occur in the southern part of the area in Christie Brook. Because of the scarcity of fossils in the Canso and Horton sediments, accurate separation of the two groups is extremely difficult in the south-central part of the area.

Riversdale Group

Lower Pennsylvanian, non-marine sediments of the Riversdale Group underlie a strip about 3 miles wide extending eastward across the map area. On the south they make a fault contact with Horton, Canso, Windsor and Triassic sediments; while on the north they are separated from sediments of the Pictou Group by another east-trending fault. Riversdale sediments consist of grey, fissile sandy shales, grey sandstones interlensed in the shales and black coaly shales. The strata are evenly bedded and show both mud cracks and ripple marks. The sandstones, commonly massive and crossbedded, contain numerous plant remains and petrified tree roots which are often several feet long.

Pictou Group

A band of upper Pennsylvanian rocks about 3 miles wide lies in faulted contact with, and to the north of, the Riversdale sediments and extends eastward across the map area. These rocks constitute the Pictou Group and are also in fault contact with older Canso rocks and the Cobequid complex lying to the north. Lithologic similarities and the absence of fossils in the conglomerates and coarse sandstones of the Cumberland and Pictou Groups make it difficult to differentiate between the two. In general, these strata are a mixed assemblage of rocks that range in grain size from coarse conglomerates to fine shales. Locally, thin beds of lenticular conglomerate occur in the sandstones and shales. The sandstones are crossbedded and the shales show ripple marks.

Fundy Group

Triassic sediments belonging to the Wolfville Formation of the Fundy Group lie in the eastern end of the synclinal basin which extends from about the centre of the map area westward to the western portion of the Annapolis-Cornwallis Valley. These terrestrial sediments dip about 5° toward the Bay of Fundy and overlie with angular unconformity the older Carboniferous strata to the south. The Wolfville Formation is noted for the heterogeneous distribution of its constituents and their consistent red colour. It consists mainly of interbedded roundstone and sharpstone conglomerate and coarse and medium grained sandstones. It is crudely stratified and shows lateral changes in thickness (Klein, 1962). Poor sorting, crossbedding, channelling phenomena in the sandstones, and subangularity in shape of the pebbles in the conglomerate are indicative of transportation and deposition by torrential streams. The sediments were probably deposited in the form of flood plains and perhaps in part as broad, alluvial fans. Klein, 1962, states that the Wolfville Formation in the map area is composed of low-rank graywacke and orthoquartzite as classified according to Krynine (1948), with matrix consisting of an average of 3 per cent of quartz and mica and 14 per cent sparry calcite cement.

To the north these strata are separated from older Carboniferous rocks by the Cobequid fault which extends from West Advocate to a point northeast of Truro, a distance of 90 miles.

The true thickness of Triassic sediments is not known but there is at least 1000 feet exposed along the Debert River (Stevenson, 1958). A test hole (index no. 299) drilled at Bible Hill penetrated over 600 feet of these rocks.

Surficial Deposits

Of the glacial drift in the area, till is by far the most abundant surficial material and covers over three quarters of the map area. The remaining area is covered by deposits of stratified sand and gravel and clay of recent and glacial ages. Generally the deposits are thickest in the lowland areas and consist of stratified sands and gravels, while the topographic high areas are usually covered with a thin mantle of till.

The surficial deposits mapped in this area may be divided into six main classes: till, glaciofluvial and glaciolacustrine deposits; peat and muck; stream alluvium; dykeland; salt marsh and tidal flat.

Glacial Till

Till is unstratified unsorted glacial drift, deposited by glaciers without subsequent movement by wind or water. It consists mainly of mechanically broken fragments, ranging from clay to boulders, of nearby bedrock. The proportions of the various sizes of material depend upon the nature of the source rocks (Thwaites, 1957). Till is perhaps the most variable sediment known by a single name. It may consist of 99% clay particles, or 99% large boulders, or any combination of these and intermediate sizes (Flint, 1963).

The till mapped in the area was divided into two main distinct types: clay till and granular or sandy till. Clay till is the most abundant, covering nearly one-half of the map area, whereas a granular till covers about one-third the area.

Clay till is generally confined to areas underlain by bedrock units of predominantly silts and shales, i.e. the Riversdale, Canso, and Horton groups. Wide variations in the compactness of the clay till were experienced throughout the area. Flint (1963) states that most till containing more than 10 per cent clay or more than 40 per cent clay and silt combined tend to be massive and compact. Other factors affecting compaction are physical settling, cementation and static pressure of overlying ice.

The granular till was mainly confined to areas overlying bedrock units of predominantly granites, conglomerates and sandstones, i.e., the Cobequid

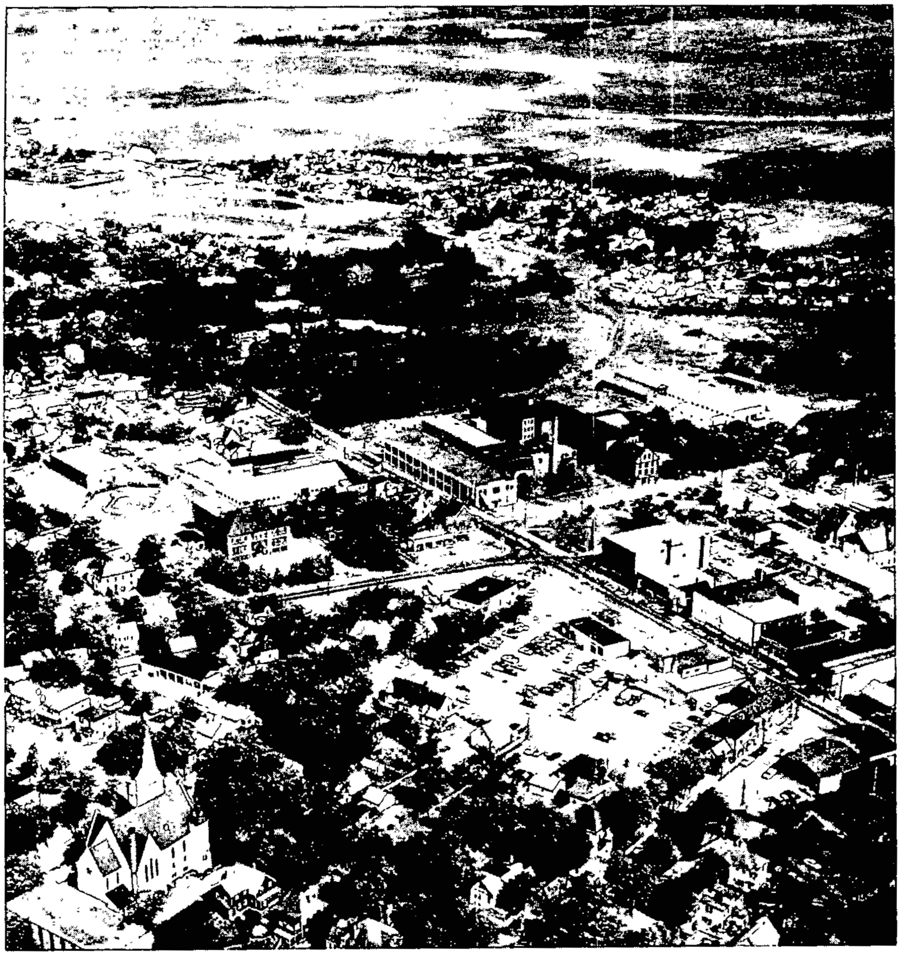


Figure 5. View of terrace development in Truro with dykelands and Salmon River in top of photo (view northeast). (Photo by Film and Photographic Section, N. S. Dept. of Tourism.)

granites, and Pictou and Triassic sediments. Thwaites (1957, p. 30) states that hard rocks like granite have widely spaced fractures and so break chiefly into boulders and large pebbles. Till derived from sandstone is largely unstratified sand mixed with some pebbles, boulders and silt.

A good correlation between till composition and underlying bedrock types exists in areas where sandy till overlies the Triassic sediments consisting predominantly of conglomerates and sandstones. Nowhere in the map area was a clay till found overlying coarse Triassic sediments. Along the contact of the Triassic sediments and Riversdale shales, the sandy till-clay till contact almost exactly coincides with the bedrock boundary.

Two areas of hummocky moraine were mapped, both of which overlayed coarse grained bedrock deposits. One large hummock of sandy moraine materials (see Fig. 6) overlies the coarse-grained granitic area of the Cobequid complex in the north portion of the map area (see Map 1). This material, which has the form of a drumlin, consists almost entirely of particles identical in colour and texture to those comprising the underlying granite. The second area of hummocky moraine material occurs in the east central portion of the map area. Here most of the hummocks are composed of a granular till derived from the underlying sandstones and conglomerates of the Pictou Group. Hogg (1953) reports that hummocky ground moraine areas in Pictou County, along the flanks of the Cobequids, east of the map area, consist of a gravelly and porous material.

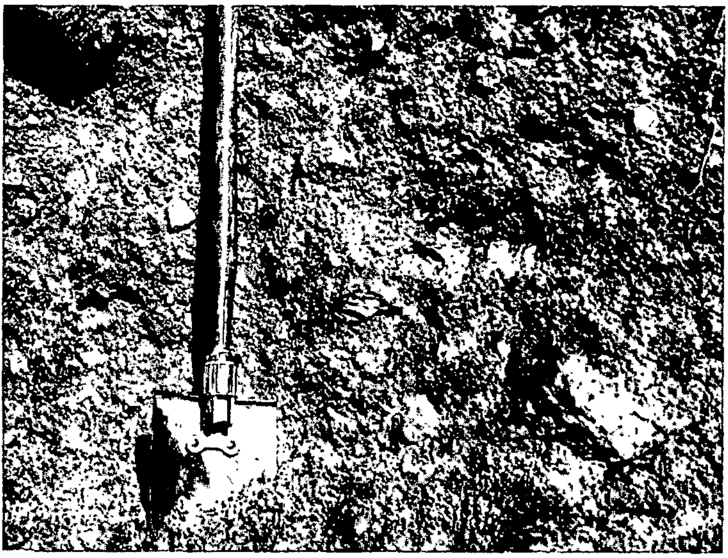


Figure 6. Granular till overlying the Cobequid Complex.
McCallum Settlement, 11 E 11 B 16 G (view east)

Glaciofluvial Deposits

Glaciofluvial deposits in the study area may be broken down into two main groups: ice-contact stratified drift and outwash deposits.

Accumulations of stratified drift built in immediate contact with wasting ice are collectively referred to as ice-contact stratified drift or simply as ice-contact features (Flint, 1963, p. 136). They include eskers, kames, and kame terraces. Thwaites (1957, p. 32) defines glaciofluvial deposits as glacial drift which was not deposited directly by the ice but was carried, sorted, and deposited by streams derived from the melting of the glacier. Using this definition, both ice-contact deposits and outwash deposits may be classed as glaciofluvial. This may be convenient as a practical reference to the type of materials deposited when their mode of origin is not being considered.

In general, ice-contact deposits of sand and gravel occur in local topographic low areas throughout the map area. These local "low" areas resulted in the accumulation of sediments carried by glacial melt water which came from ablating blocks of ice filling the drainage channels. In some areas, North River in particular, the remnants of these deposits were observed to grade into the surrounding till cover on the slopes of steep valleys (see Fig. 7).

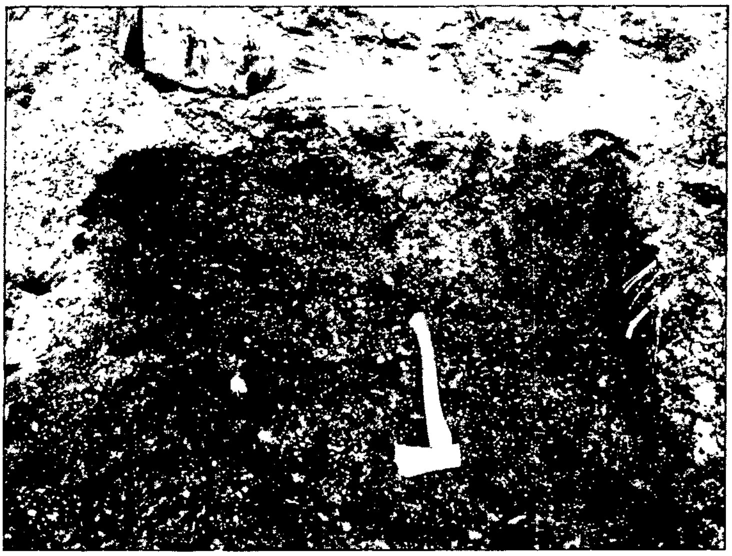


Figure 7. Remnants of ice-contact stratitied dritt on steep valley slope, North River, 11 E 6 C 72 Q (view east)

Kames are irregularly shaped hills or mounds resulting from ice-contact stratified materials deposited by glacial meltwater in crevasses or other openings in ablating ice. They are generally composed of bedded sands and gravels which show extreme variations in sorting both vertically and horizontally (see Fig. 8).

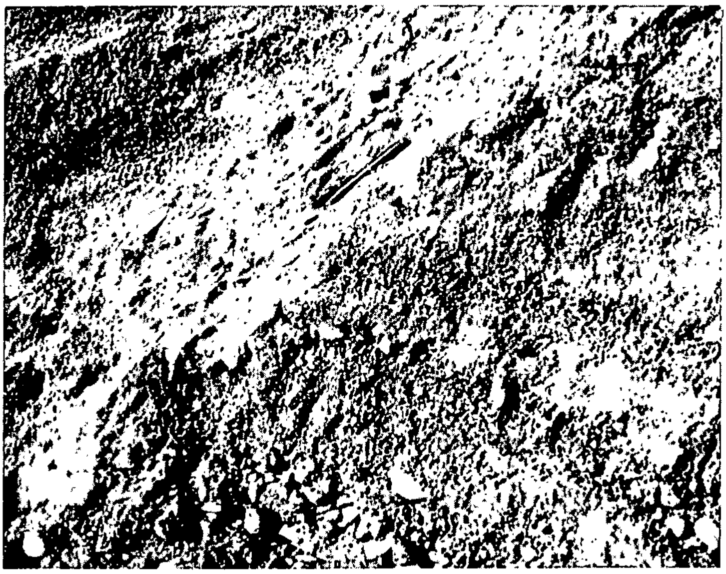


Figure 8. Variations of bedding in kame, Greenfield
11 E 6 A 102 P (view north)

The most spectacular kame in the map area is located south of Riversdale in a small isolated area of ice-contact stratified drift. This feature is roughly oval shaped and about 600 feet long and 300 feet wide at the base. It is steep sided and reaches a height of about 50 feet. In this deposit, fine sand is interbedded with coarse gravel, both showing excellent crossbedding.

Materials composing kames in the Debert area show an interesting similarity to the lithology of the regional bedrock geology where the source material is known and the distance of transportation can be determined. In this area some of the kames overlying Triassic sediments are composed predominantly of particles derived from the Pennsylvanian sediments lying adjacent to the north.

The most distinctive form of ice-contact stratified drift is the esker, a long narrow ice-contact ridge commonly sinuous and composed chiefly of stratified drift (Flint, 1963, p. 152). An esker sometimes has distinct tributaries since it is often the deposit of a glacial stream either in an ice tunnel or an open crack. Eskers in the map area are composed of poorly sorted, irregularly bedded sands and gravels which alternate abruptly.

Four eskers occur in the map area: two may be part of the same deposit in the northern part of the area; the other two are in the southern part of the area. All, however, are formed on or near topographic highs (see Fig. 9).

Figure 9. Cross-section of esker, Archibald,
11 E 6 A 80 K (view south)

Kame terraces are accumulations of stratified drift laid down by streams between a glacier and an adjacent valley wall and left as a constructional terrace after disappearance of the glacier (Flint, 1963, p. 149). They consist of coarse sands and gravels which are poorly sorted and irregularly bedded. The largest and most prominent terraces in this area occur along the main channel of the Salmon River near Kemptown. These terraces, about one-half mile wide, border both sides of the river and extend downstream for over two miles. Other terraces exist along the North River valley and on the Black River above Riversdale.

Outwash is stratified drift which has been transported by streams originating within the glacier and deposited beyond the glacier itself. The material is characteristically coarse grained, well sorted and stratified in thin foreset beds. Variations in grain size are sharp and numerous both horizontally and vertically (Flint, 1963, p. 136).

The largest outwash deposits in the map area occur along the North River where terraces of outwash material flank the east side of the North River flood plain (see Fig. 10). In this terrace, which continues for over two miles, the bedding is well defined, continuous, and in some places shows very good sorting. The material ranges from crossbedded, well sorted sands to coarse gravels containing boulders in many places.

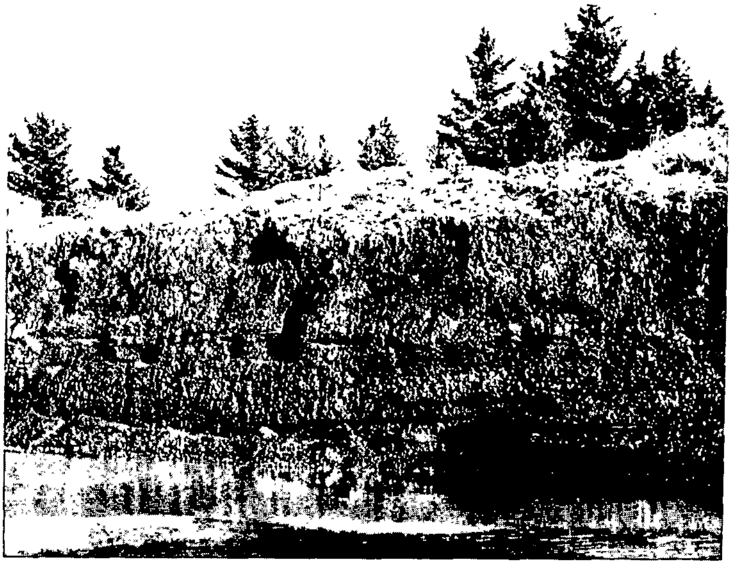


Figure 10. Outwash sand and gravel terrace, North River, 11 E 6 C 24 L (view east)

The Town of Truro is located on an irregularly shaped terrace of outwash materials. The more regular eastern portion of this deposit originated from glacial meltwaters draining the Salmon River watershed, but the western portion, which is incised and irregular in form, probably received sediments from both the North and Salmon Rivers during ablation. Cuts in the terrace at Truro indicate a very similar type of material and structure to that in North River.

Glaciolacustrine Deposits

Glaciolacustrine deposits of clay and silts occur south of Truro in the Hilden-Brookfield area. Located within the silts and clays are interbedded strata of sand which occur at various depths. Test drilling indicated that over 100 feet of these materials overlie the Windsor rock in the Brookfield area. These silty-clay deposits are very loose and extremely easy to penetrate with drilling equipment. The interbedded sands are believed to be glaciofluvial materials deposited as interglacial streams incised these soft lacustrine sediments.

Peat and Muck

Swampy deposits of peat and muck are found in many depressions both in the lowland and upland areas. Extensive areas with these types of deposits indicates poor drainage conditions.

Stream Alluvium

Alluvial deposits are found along most of the main streams in the area. Along the bottom portions of the North and Salmon river valleys, recent alluvial deposits cover broad floodplains. In general, the material consists of clay, silt, sand and gravel deposited by the stream at periods of high flow when the rivers overflow their normal channels. Deposits along the North and Debert rivers are commonly the coarsest found in the area and consist mainly of material from about 2-6 inches in diameter. In the lower reaches of the North and Salmon rivers, recent deposits overlie considerable thicknesses of outwash sands and gravels in which the present rivers have incised themselves. At Murray and Upper Onslow, deposits of sand and silt (up to 6 feet thick) form the recent flood plains which overlie buried channels filled with outwash sands and gravels (see Map 2).

Alluvial deposits of well sorted medium sized sand occur interbedded within the lacustrine silts and clays and have been drilled and sampled in the Brookfield area.

Dykeland, Salt Marsh and Tidal Flat

The tidal estuaries of the North and Salmon rivers have been dyked to protect valuable and rich pasture and hay land. The materials making up the dykelands are fine sediments of sand, silt, and clay, deposited by tides or by streams in the salt water at the mouths of the principal rivers. The area is flat, with a small natural slope toward the Bay. These deposits are about 6 feet thick and overlie outwash sands and gravels which are over 130 feet thick.

Outside the dykes, active deposition of silt and clay occurs on the salt marsh and tidal flat. The tidal flat is covered twice daily by the large fluctuation of the Bay of Fundy tides, whereas the salt marsh is the intermediate area flooded only periodically by tidal water.

Buried Channels

Two well-defined buried river channels were found incised in the soft Triassic sediments underlying the area, north and east of Truro. The largest and deepest channel, that of the North River, has been traced for a distance of about 4 miles north from Truro. The second channel, that of the Salmon River, (see Map 2) has been traced for a distance 5 miles east from Truro. Surficial deposit test-holes illustrated in Appendix A reveal the dimensions and the distribution of materials filling these channels. Under the northwest part of the town, the channels appear to merge into a larger channel which continues westward under the Cobequid Bay. Washed deposits of sand and gravel over 80 feet thick fill the North River channel, which reaches a width of about three-quarters of a mile. Similar coarse, water-washed clastics fill the Salmon River channel to depths of over 50 feet. Passing under the town from the east, this channel reaches widths of about one-quarter mile. To the west of town, where the dyke lands are constricted to a width of less than three-quarters of a mile, the main channel is over 130 feet deep and narrows to about one-half mile wide. It is suggested that the gradual increase in the depth of both channels is quite uniform in a general downstream direction, possibly indicating the stream profile or gradient of the preglacial drainage systems. Both buried channels follow the same general flow direction as the present surface streams after which they were named. A common flood plain was shared by the two streams northwest of Truro in the general area of their junction before their river mouths were "drowned", thus creating the present dykeland, which extends inland from the constriction for several miles.

It appears that the area east of the constriction, which begins just west of the Board Landing bridge, was a relatively deep sub-basin before and during the Pleistocene epoch. A sea level only 50 feet lower than the present one, combined with very high river flows during an interglacial period, could easily account for erosion of the main channel. During a later interglacial interval or later in the same interval, this same basin would be filled with glacial outwash sediments. Another buried channel was outlined in the Brookfield area where the direction appears to parallel the present drainage system. These deposits of medium to coarse sands are about 30 feet deep and overlie the Windsor Group of sediments.

It is suspected that similar water bearing materials exist in the Debert and Hilden areas where considerable depths of overburden have been reported in well drillers logs.

Structure

In general, the strata in the study area have been extensively folded and faulted into structural patterns which are evident in the geomorphological make-up of the area.

The younger Triassic rocks, which are only slightly folded, exhibit a low broad synclinal structure which trends in an easterly direction. Major east-trending faults limit the extent of the Triassic in the north, while numerous north-trending faults in the sediments result in minor displacement.

Two regional strikes, one southwest for the Mississippian strata, and the other east for the Pennsylvanian strata, indicate the presence of two distinct sets of folds. The early, southwest-trending set affects the Mississippian sediments in the south part of the map area; while the later, east-trending set folded the Pennsylvanian strata lying in the north portion of the area. The major southwest-trending folds in the map area have been named the Truro anticline, which terminates at the Triassic-Horton contact in the southern part of Truro, and the Greenfield syncline, which transverses the Canso sediments just southeast of Fraser Brook (Stevenson, 1958).

Two major east-trending folds were identified in the Pennsylvanian strata in the northern portion of the area (Stevenson, 1958). The axis of the Debert River syncline is enclosed in, and parallels, the Pictou group, whereas the North River anticlinal axis lies in the Riversdale Group just south of the fault contact with the Pictou group.

Faults in the area form two distinct systems, an earlier west, and a later north-trending system. The west-trending system, the largest and most important of the two, consists of three major faults: the Cobequid, North River and the Riversdale faults. In addition, the strata have been cut by numerous other faults showing irregular attitudes, small displacements and no distinct pattern.

HYDROLOGY

Introduction

The science of hydrology provides a tool with which man can determine the quality and volume of water available to him for his own use and for application in agriculture and industry. The basic hydrologic equation:

$$\text{Inflow} = \text{Outflow} \pm \Delta\,\text{storage} \qquad (1)$$

expresses the principle that during a given time interval the total inflow to an area must equal the total outflow plus the net change in storage.

A comprehensive definition of the hydrologic budget is given in Schicht and Walton (1961, p. 8):

> "A hydrologic budget is a quantitative statement of the balance between the total water gains and losses of a basin for a period of time. The budget considers all waters entering and leaving or stored within a basin. Water entering a basin is equated to water leaving a basin, plus or minus changes in basin storage."

The hydrologic budget is calculated on the basis of the water year (October 1 to September 30) because surface water discharge and groundwater storage are generally at a minimum at the beginning and end of the period. When stated as an equation including all of the items that may be involved, the hydrologic budget is:

$$Pr + Sur\ I + Sub\ I + Imp = R + ET + U + Exp \pm \Delta Soil \pm \Delta Ss \pm \Delta Sg \qquad (2)$$

where:

Pr = precipitation
Sur I = surface inflow
Sub I = subsurface inflow
Imp = imported water
R = stream flow (surface and groundwater runoff)
ET = evapotranspiration
U = subsurface outflow
Exp = exported water
Δ Soil = change in soil moisture
Δ Ss = change in surface water storage
Δ Sg = change in groundwater storage

The items of this equation for which values were determined are discussed in the following sections.

Precipitation

Precipitation is defined as the various forms of moisture (rain, sleet, snow, hail, dew, and fog drip) which fall from the atmosphere to the earth. Within the map area, rainfall accounts for over 80 per cent of the mean annual precipitation and is thus the main element of discussion in this report. In general, rainfall diminishes with distance from the sea coast and increases with elevation above sea level.

Long term records of precipitation have been kept at four stations in and adjacent to the map area. Data in these records cover the period from 1931 to the present. At Truro and Upper Stewiacke the records are nearly complete for the full period. At Clifton and Debert from 10 to 35 years of records are available during the same period. At Fraser Brook instrumentation was installed in 1965 under the International Hydrological Decade program.

Temporary precipitation sites were established throughout the Salmon River watershed and instrumented with standard rain gauges in June 1967. The main purpose of this network was to indicate the consistency of variations in rainfall across the watershed. It was felt that changes in physiography, topography and distance from the seashore in this area affected the amount and aerial distribution of precipitation in the map area.

Precipitation instrumentation within the area was therefore placed in three main groups: established gauge sites that have been in operation since 1931; instruments installed under the I.H.D. program in 1965; and temporary instruments throughout the Salmon River watershed established in June 1967. A discussion of the various records at these sites is included below.

Precipitation at Truro and Other Established Instrument Sites

Precipitation normals calculated for the established sites are listed in Table 5. Note that mean annual precipitation at the Truro site is the lowest of the four. An examination of mean monthly data, however, reveals that only during the months of February, May and August is precipitation at Truro less than at any other site. Also, there is no month during which the mean precipitation at Truro is the greatest of the four stations. Another interesting pattern shows that during the months of September and October, the precipitation is greater at Truro than the average of the four sites. During ten months of the year, records at Truro thus indicate less precipitation than actually does occur on the eastern part of Colchester County.

Table 5. Precipitation normals for established sites in the study area.

Month	Truro[1]	Debert[2]	Upper Stewiacke[1]	Clifton[2]	Mean
January	4.16	4.58	3.92	5.38	4.51
February	3.47	4.03	3.76	4.24	3.88
March	3.10	3.65	3.05	3.71	3.38
April	2.90	3.70	2.87	3.35	3.21
May	3.13	4.12	3.35	3.30	3.48
June	2.82	3.37	2.89	2.30	2.85
July	2.92	3.41	3.08	2.72	3.04
August	3.37	4.70	3.49	4.16	3.93
September	3.94	4.08	3.97	3.44	3.86
October	3.40	3.27	3.45	3.09	3.31
November	4.62	5.60	4.46	5.38	5.01
December	3.89	4.11	3.50	4.47	3.99
TOTALS	41.72	48.62	41.79	45.54	44.40

N.B. 1. Data from 25-30 years of records between 1931-1960
2. Data from 10-24 years of records during period 1930-1960

The mean annual precipitation at Truro, 41.7 inches, is 6.9 inches (about 15%) less than the highest (recorded at Debert). It is also 2.7 inches less than the mean normal of the four sites, which is 44.4 inches. This represents a discrepancy of about minus 6 per cent. To apply the Truro mean figure to the Salmon River watershed above Murray, for example, would indicate an inflow of about 310,000 acre-feet. The maximum, Debert, data would indicate about 362,000 acre-feet, while a mean precipitation of 44.4 inches is equivalent to about 330,000 acre-feet of water on the watershed. From these figures, the Truro data gives an underestimate of about 20,000 acre-feet per year less when compared to the overall mean data. This is equivalent to about 7 times the volume of water presently being utilized annually in the map area.

Salmon River Watershed Precipitation Gauge Network

Discussion of the amounts and variations of precipitation over the Salmon River watershed is based on records collected during part of 1967 and 1968. These records from sixteen locations across the map area show wide variations in the monthly total (see Table 6). The highest total for this period was recorded near Dalhousie settlement in the northeast part of the map area (site 10). Also included in Table 6 are the values at the established Truro site (no. 14) and the mean values for the sixteen sites.

Table 6. Precipitation on Salmon River watershed (1967 & 1968)

	SITE NO.															
1967 MONTH	1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	MEAN	COEFFICIENT OF VARIATION
July	5.26	4.30	4.95	3.72	5.32	2.78	3.91	4.06	2.62	3.64	4.01		4.85	6.35	6.08	4.47	37.30
Aug.	3.38	4.19	3.42	3.61	3.80	2.90	3.97	3.06	3.78	3.93	3.90	5.05	3.26	3.93	3.66	3.72	13.38
Sept.	4.40	3.70	4.32	4.82	4.63	4.82	4.71	4.57	4.56	6.37	5.45	5.97	4.43	5.90	5.30	4.93	14.20
Oct.	5.28	5.51	6.53	5.99	6.53	6.20	5.52	5.77	5.88	6.71	6.87	6.23	5.96	6.38	6.24	6.11	7.33
Nov.	5.12	5.98	8.26	7.26	7.75	3.81	5.81	6.40	6.70	8.32	6.71	6.95	5.59	6.95	6.73	6.56	17.51
Dec.	5.20	4.44	5.21	4.66	6.60	2.93	5.91	5.89	5.19	5.35	4.46	5.40	5.57	6.15	7.03	5.33	17.92
TOTALS	28.64	28.12	32.69	30.06	34.63	23.44	29.83	29.75	28.73	34.32	31.40	29.60	29.66	35.66	35.04	31.12	
1968																	
Jan.	2.09		4.65	3.20	5.37		4.60	3.66	2.81	5.28	2.11	4.50	3.47	3.49	4.08	3.79	47.78
Feb.			2.31	3.28	2.76		2.07	2.52	1.92	2.95	1.89	1.75	2.45	2.56	2.61	2.42	53.19
Mar.	4.58	6.59	2.66	4.15	5.90	3.44	4.24	4.17	3.85	4.38	3.83	4.34	4.04	2.81	3.73	4.18	23.26
Apr.	2.33	2.69	3.13	3.24	3.59	3.35	3.22	2.94	3.29	3.41	3.07	3.00	2.70	3.30	3.01	3.08	10.15
May	1.70	1.82	2.61	2.32	2.22	0.88	2.07	2.32	2.68	3.77	2.54	2.45	1.84	2.76	2.43	2.29	26.61
June	3.15	3.32	4.29	3.95	3.42	4.64	3.60	4.04	3.87	4.12	4.21	4.32	3.67	4.21	3.79	3.91	10.29
July	0.98	0.76	0.62	1.39	0.61	0.15	0.71	1.16	0.80	1.39	1.28	0.76	1.34	1.00	0.74	0.91	37.27
Aug.	4.84	4.98	4.88	4.75	4.69	4.81	4.72	4.02	4.36	4.53	3.04	3.42	5.26	4.73	4.66	4.51	12.71
Sept.	1.39	1.65	2.06	1.98	2.27	2.32	1.60	2.11	2.84	3.12	4.78	2.16	2.66	2.09	1.97	2.33	33.81
Oct.	3.05		3.95	4.61	3.64	2.71	3.47	4.01	3.74	4.87	4.42	2.99	3.17	3.44	3.57	3.69	31.42
Nov.	6.00			7.48	7.42	3.96	6.96	7.17		8.18	7.90	7.71	6.08	7.43	7.08	6.95	52.43
Dec.	4.51			5.09	7.90		7.31	6.43		8.30	5.50	7.59	5.87	6.43	6.70	6.51	62.82
TOTALS				45.44	49.79		44.57	44.55		54.30	44.57	44.99	42.55	44.25	44.37	44.57	

To give some idea of the magnitude of variation in rainfall at the sites throughout the watershed, the coefficient of variation (V) was used (Moroney, 1951). This is a measure of relative variation between the totals at the various sites and the mean.

Values of V varied from about 7% up to almost 63% (see Table 6). These data indicate a notably non-uniform precipitation across the study area.

Determination of Average Precipitation on the Watershed

Measurements of precipitation with a rain gauge give the depth of moisture in inches that falls on the earth at the site of the gauge. Where several gauges are employed in an area, the values of the points are used to determine an average amount over the area. The accuracy of this value is determined largely by the density of the gauge network, siting and spacing of the gauges and orographic effects. Also, large differences in precipitation are observed in short distances in mountainous terrain or during showery precipitation in level country. Therefore, various techniques or methods are used for computing the average precipitation over a given area. Two objective methods are applied for areas smaller than 2000 square miles. For small areas up to 200 square miles and reasonable uniform spacing of the rain gauges, the arithmetic mean is usually sufficient. For intermediate areas of 200 to 2000 square miles with small orographic effects, Thiessen's method may be used (DeWiest, 1967, p. 29).

If the precipitation is non-uniform and the stations unevenly distributed within the area, the arithmetic mean may be incorrect. To overcome this error, the precipitation at each station may be weighted in proportion to the area the station is assumed to represent; this is accomplished with the Thiessen network.

> "A Thiessen network is constructed by connecting adjacent stations on a map by straight lines and erecting perpendicular bisectors to each connecting line. The polygon formed by the perpendicular bisectors around a station encloses an area which is everywhere closer to that station than to any other station. The area is assumed to be best represented by the precipitation at the enclosed station. The average rainfall is the sum of the individual station amount, each multiplied by its percentage area."
>
> (Linsley and Franzini, 1964, p. 13)

For a period from July to November, the average precipitation over the watershed was determined by both the arithmetic mean and the Thiessen network. From the results, summarized in Table 7, the mean values differ the most for the month of July. Since the stations are evenly distributed throughout the watershed, this variation in measurement must be due to non-uniform precipitation in the area. With this assumption and the fact that the Thiessen network weights the precipitation and areas, the mean determined by using the network is more accurate. Although there is not enough evidence to show what is causing the variation, it is felt that local showery activity is contributing the major portion of the difference.

Table 7. Average values of precipitation in inches over the Salmon River Watershed, 1967

Month	Arithmetic Mean (inches)	Thiessen Network (inches)	Difference (%)
July	4.34	4.05	+6.0%
August	3.84	3.82	+0.5%
September	4.95	4.85	+2.0%
October	6.09	6.14	-0.8%
November	6.75	6.98	-3.4%

Commonly, the two major factors affecting the amount of precipitation on an area are the elevation of the land area, and the distance of that land area from the seashore (Linsley and Franzini, 1964). Butler (1957) indicates that the general relationship between precipitation and elevation is linear. In order to test the application of this hypothesis in the study area, a linear regression analysis was carried out using the method of least squares to fit a line to the rainfall-distance and rainfall-elevation data. To determine whether the relationships were significant, the variance of the regression coefficient (b) in each case was determined and the student t value was computed (see Steele and Torrie, 1960). The values obtained in both cases indicated that there is no reason to believe that (b) is not equal to zero. It was therefore concluded that no linear relationship exists between precipitation and elevation nor between precipitation and distance with B chance of type 11 error.

Evapotranspiration

Potential evapotranspiration (PE) is one of the more important components of the hydrologic equation. By assuming that all precipitation enters the soil when the soil is below field capacity (the volume of water retained by the soil against gravitational drainage), it is possible to compute the water deficiency and water surplus for an area. In areas where there is a water deficit (when the soil moisture is less than field capacity) during the growing season, actual evapotranspiration (ET) (the amount of water actually lost) will be less than the potential amount. The Department of Forestry and Rural Development of Canada (1966) assume a soil moisture holding capacity of 4 inches. Thus a moisture deficiency does not exist until the PE exceeds the precipitation by 4 inches during the growing season.

Instrumentation in the I.H.D. basin at Fraser Brook provided direct measurements in evaporation by use of the internationally adopted "Class A Pan". Table 8 presents evapotranspiration data from two different methods for comparison in the map areas. In the Freeze program, a soil moisture capacity of 8.8 inches was assumed.

Table 8. Evapotranspiration, Truro Area, 1968

	Fraser Brook Precipitation	Evaporation From CLASS A PAN Fraser Brook	Adjusted Lake Evaporation (Actual)	ET Calculated by Freeze Program (1967) at Truro (Actual)
April	3.01	no record	no record	1.18
May	2.36	3.56	2.50	2.10
June	3.79	3.93	2.75	3.43
July	0.74	6.34	4.44	4.88
August	4.66	5.62	3.93	3.91
September	1.98	2.89	2.02	2.03
October	3.54	2.09	1.46	1.91
November	7.08	0.32	-	0.20
TOTALS	27.16	24.75	17.10	20.64

A study in arid and subhumid areas in the United States to correlate the PE obtained by several empirical methods (the Thornthwaite method being one) with adjusted pan evaporation measurements indicated several variations in the methods. Results obtained by using the Thornthwaite method were consistently low.

> "Values of potential evapotranspiration computed by the Thornthwaite method were less than the adjusted pan evaporation at all sites used in the study. The differences ranged from -21 to -66 per cent for the entire year and from -10 to -63 per cent for the growing season."
>
> (Cruff and Thompson, 1967, p. 19)

Potential evapotranspiration calculations by the Thornthwaite and Penman method, Holmes and Robertson Moisture Budget Technique, were used in this report by employing a computer program by Freeze (1967).

The Thornthwaite method employs an empirical equation which relates the potential evapotranspiration to the mean air temperature. The Penman method is a combination of an empirical sink-strength formula and the theoretical energy balance approach.

The purpose of the Holmes and Robertson (1960) moisture budget is to arrive at monthly values of the moisture storage, moisture surplus and actual evapotranspiration by comparing the monthly values of precipitation and potential evapotranspiration at a given station. The soil moisture capacities of the various soils in the area are taken into account by a budgeting procedure in which the soil moisture body accepts water from precipitation and loses it by evapotranspiration. The concept that actual evapotranspiration decreases with decreasing soil moisture content is included in the analysis. The moisture sample is the key output parameter, as this represents the amount of water available for surface runoff and groundwater recharge. Using values of the Soil Research Lab, Swift Current, Saskatchewan (1956), soil moisture capacities range from 4.2 inches for sandy loam to 8.8 inches for heavy clay.

Figure 11 (upper) shows mean monthly precipitation values for the stations at Debert, Upper Stewiacke and Truro in the map area. Included in that figure is the mean monthly potential evapotranspiration at the Truro station showing values greater than the precipitation during the months June, July, and August. The lower portion of the figure shows the difference in the mean monthly actual evapotranspiration because of the influencing effect of soil moisture capacity.

Figure 12 illustrates the mean monthly surplus and deficit of soil moisture assuming first a soil moisture capacity of 8.8 inches, and secondly a capacity

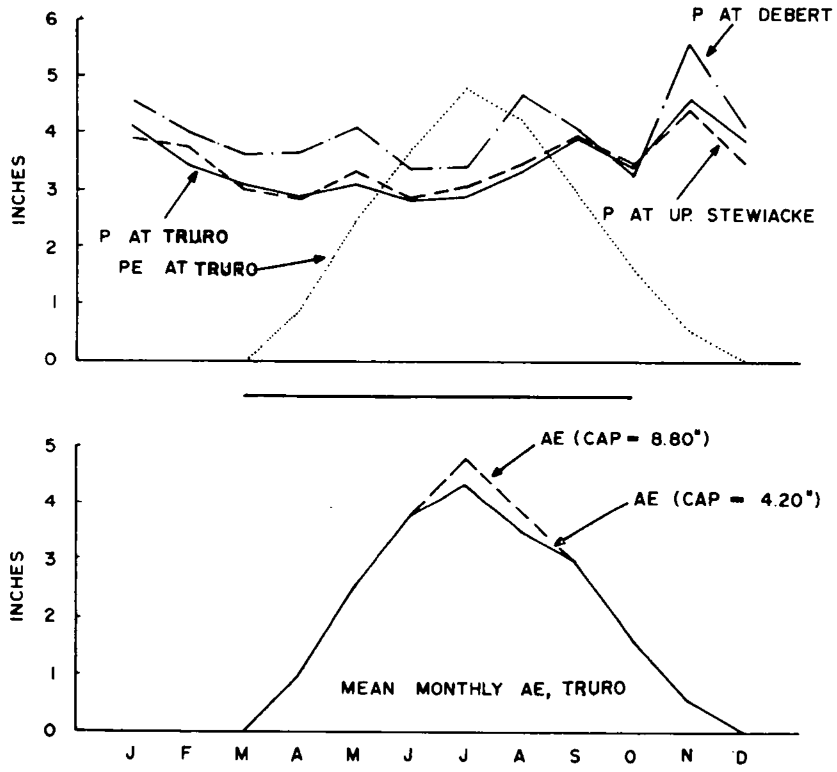


Figure 11. Mean monthly precipitation and evapotranspiration values in the study area.

of 4.2 inches. In the first case, which represents clay soils, the greatest deficit (0.41 inches) occurs in August. The mean annual total deficit amounts to 0.47 inches at the Truro station, accumulating during the months of July and August.

Sandy soils at the same site accumulated a soil moisture deficit of 1.23 inches during the same period, with 0.74 inches occurring in August. On the average, therefore, it is only during two months of the year that a soil moisture deficit occurs. There exists during the remaining ten months a surplus of soil moisture which is available for stream runoff and/or groundwater recharge.

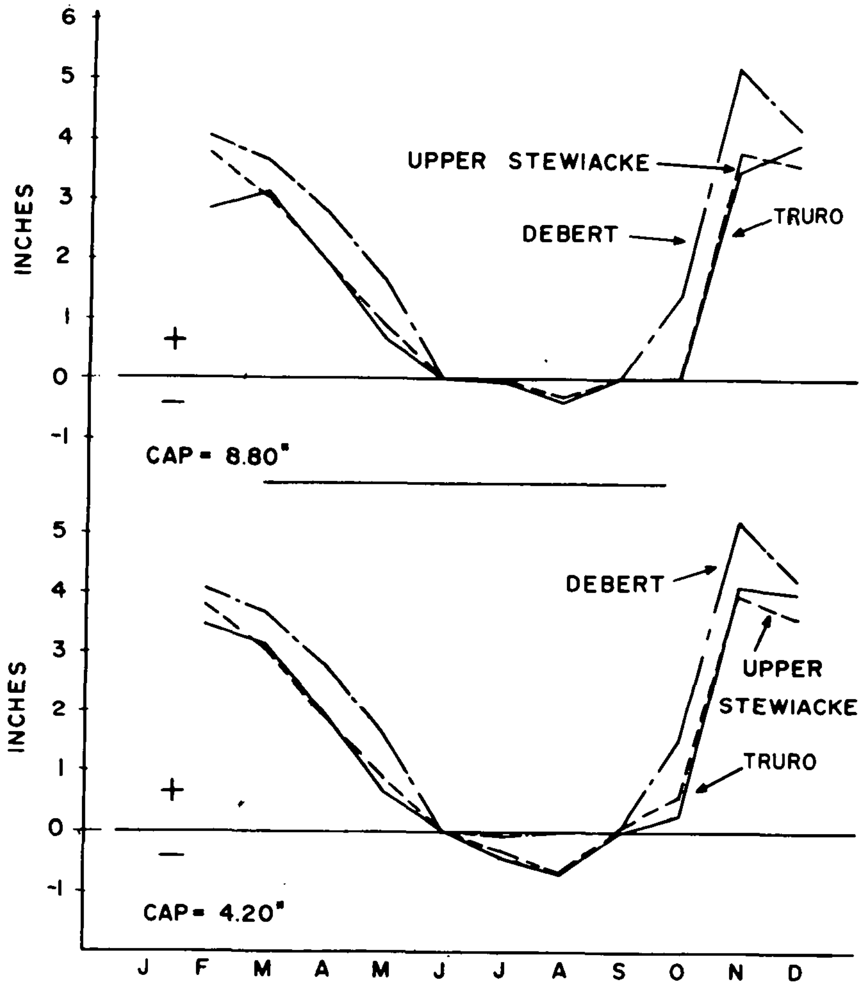


Figure 12. Mean monthly soil moisture surplus and deficit in the study area.

Note that ET begins in April, reaches a peak in July and ceases during November. During July, the mean PE exceeds the mean precipitation by 1.91 inches, indicating a heavy withdrawal of the soil moisture content to satisfy the evapotranspiration losses.

At Truro the mean annual PE equals 21.41 inches which is 44 per cent of the mean annual precipitation. This leaves 27.21 inches or 56 per cent of the total annual precipitation available for runoff and storage in the watershed. Figure 11 shows the graphic relationship between PE and precipitation for a twelve month period.

Stream Flow

Records of stream flow measurements have been collected by the Water Survey of Canada, Inland Waters Branch of the Department of the Environment on the Salmon River at Murray and at Fraser Brook. These flows are being measured by recording the river stage at the two stations and entering the recorded value in a stage-discharge relationship, or a rating curve.

Stream flow has two basic components: (1) direct runoff, that portion of precipitation reaching the stream channel by overland flow; and (2) base flow, the water discharged to a stream channel as a result of groundwater flow. A stream which continuously receives groundwater flow is effluent, its channel being below the water-table.

Of the total precipitation, the proportion which occurs as runoff depends on many factors. The most important are the rainfall intensity, rate of infiltration, soil moisture deficiency, vegetation, geology and physiography of the watershed. The volume of streamflow also varies with size of the drainage area.

The only groundwater that does not reach the streams is: (1) that which is evaporated and transpired before it can reach a stream; and (2) that portion passing underground beneath the coasts together with underflow in river flood plains, and discharging into the sea without first entering a stream. Although both types of discharge amount to a good many million gallons per day over a large area, in most areas they are insignificant in comparison to the groundwater that does reach the streams (McGuinness, 1963). The volume of groundwater discharged as stream flow is large because it supports the dry season base flow of most streams after water has ceased running into them directly over the land surface. The rest comes from lakes and swamps which, like groundwater reservoirs, provide some storage and thus delay runoff.

Rather extreme variations in the percentage of precipitation which occurs as direct runoff from storms is evident in different parts of Nova Scotia. The Water Survey of Canada Inland Waters Branch, Canada Department of Environment (Personal Communication, J. W. Byers) has found that in Nova Scotia from 7 to 76 per cent of the precipitation occurs as direct runoff. Variations in this ratio also exist at any particular river during different periods of the year. A storm on the Medway River on July 5, 1951, resulted in only 7 per cent of the water occurring as direct runoff, while a storm on the St. Mary's

River on June 21, 1959, resulted in 76 per cent of the rainfall occurring as direct runoff. It is also interesting to note that on the Medway River this percentage varies from 7 to 44 per cent, while that on St. Mary's River varies from 31 to 76 per cent. However, it should be borne in mind that the precipitation used for determining these figures was measured at only a few sites and thus may not be an accurate measurement of what actually fell on the watershed. That both these extreme values of direct runoff over precipitation occurred during the summer months when the precipitation is of a showery and scattered nature, would suggest possible errors in measurement. For example, if a shower was centered over the inaccessible and uninstrumented portion of the watershed, the measured precipitation and the direct runoff-precipitation ratio would appear much higher than it actually is. An incorrect and lower ratio would result if the storm was centered over the instrumented site.

Salmon River Runoff

Since August, 1964, a continuous record of stream flow and river stage has been kept of the Salmon River at Murray, which is the outlet for the river as used in this report and all water flowing out of the watershed does so at this point. The mean daily discharge plotted on semilog hydrograph paper for the years 1965 to 1969 appears in Figures 13 to 15.

Table 9. Summary of discharge data of Salmon River at Murray during 1965 - 1969.

Year	1965	1966	1967	1968	1969
Maximum daily discharge (cfs)	1,870 Nov. 18	2,900 April 1	3,790 May 3	3,540 Dec. 16	4,110 Dec. 23
Minimum daily discharge (cfs)	11.3 Aug. 7	7.9 Aug. 16	35.8 Aug. 26	10.8 Aug. 20	6.5 Aug. 31
Maximum monthly discharge (acre-ft)	34,570 April	41,440 March	101,100 May	54,500 Dec.	49,300 Nov.
Minimum monthly discharge (acre-ft)	1,130 Sept.	1,990 July	5,200 Aug.	2,200 Sept.	1,450 Aug.
Mean total annual discharge (acre-ft)	177,040	205,700	325,850	225,000	249,000
Unit flow (acre-ft) per day per sq. mi.	3.5	4.0	6.4	4.4	4.9

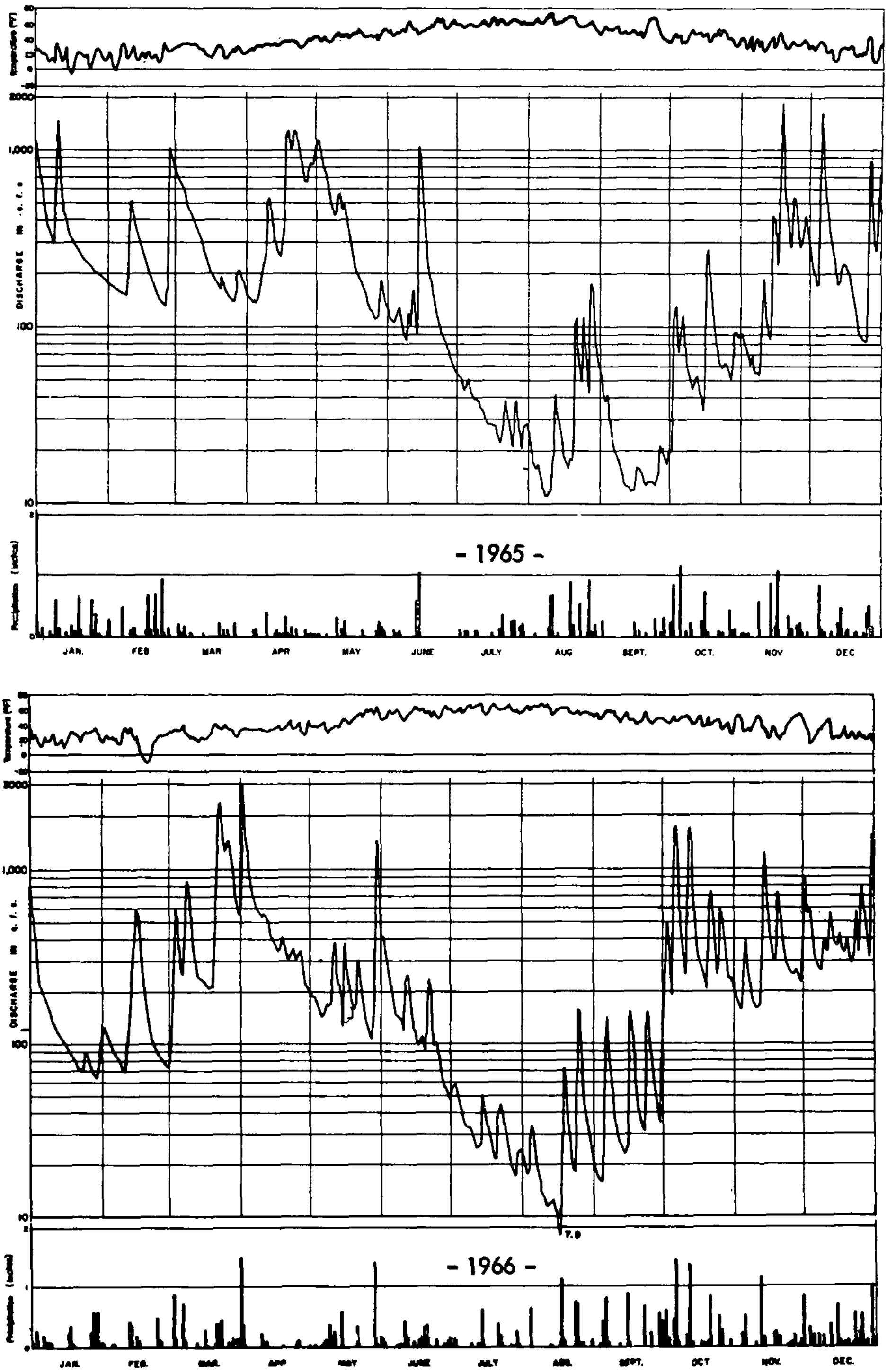


Figure 13. Discharge hydrographs of Salmon River at Murray for 1965 and 1966.

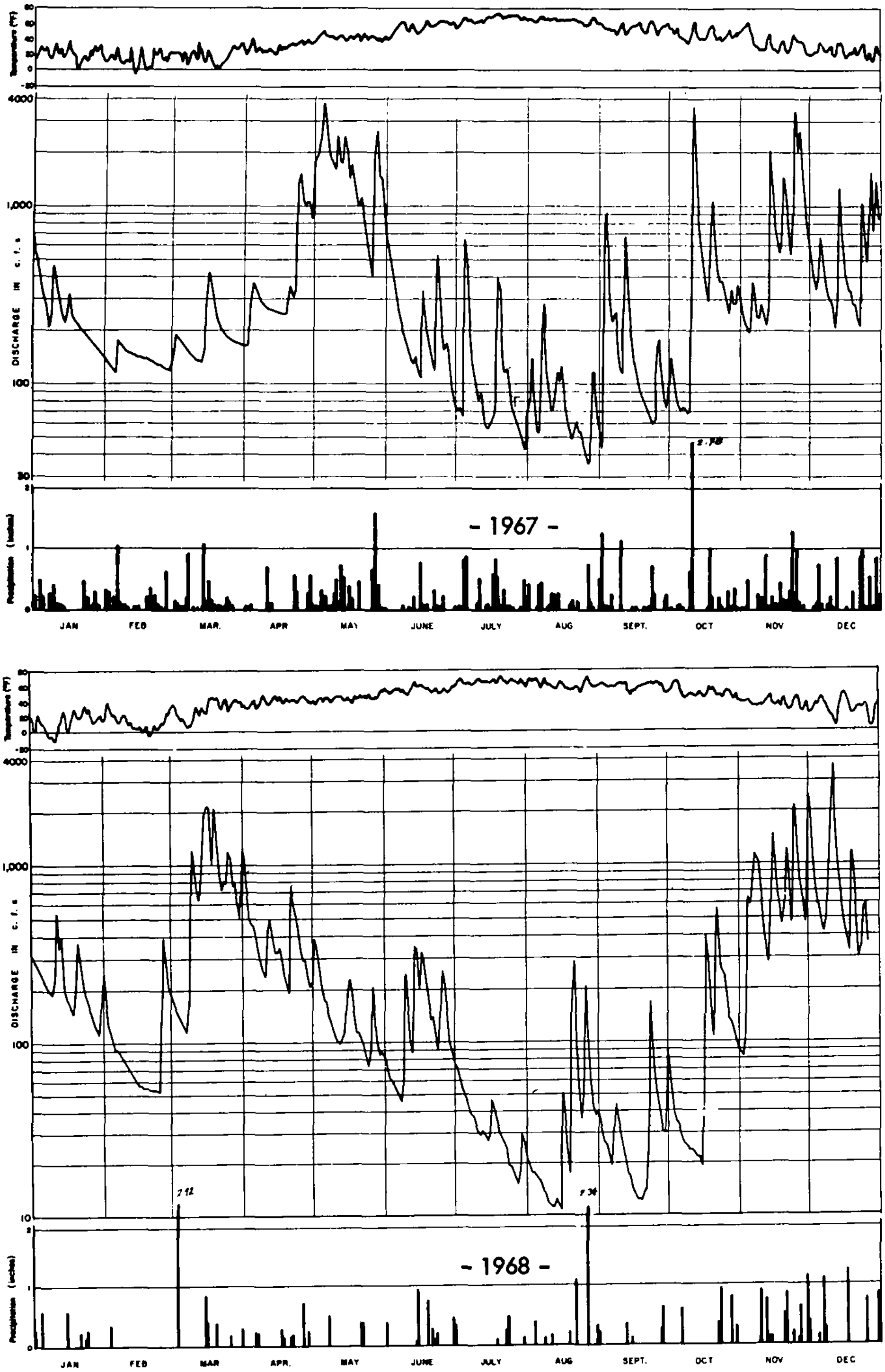


Figure 14. Discharge hydrographs of Salmon River at Murray for 1967 and 1968.

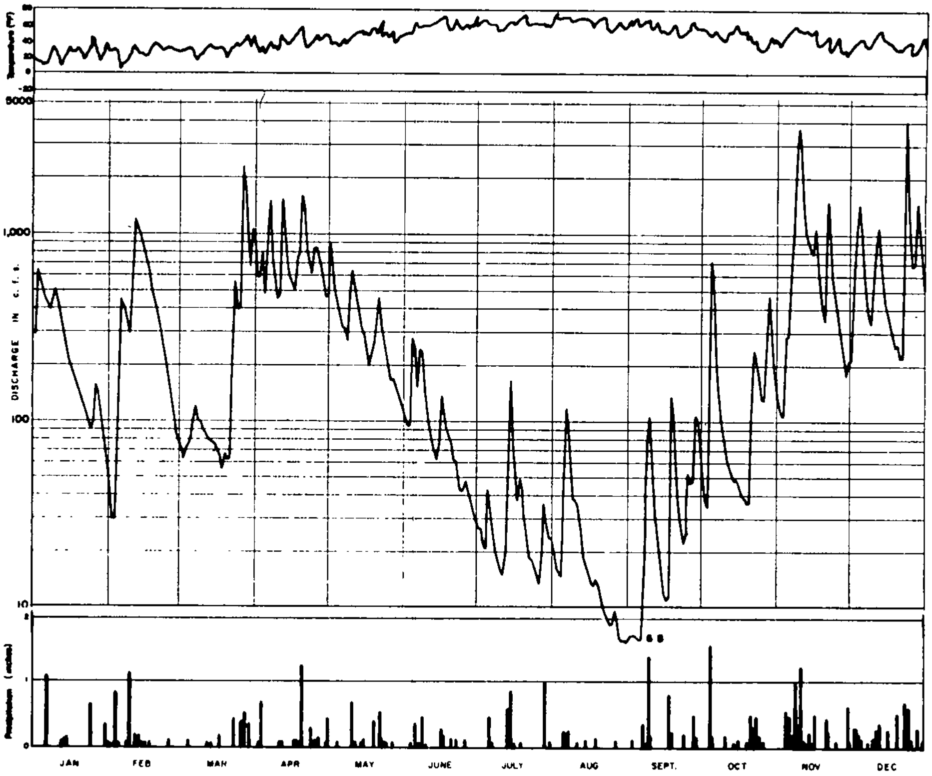


Figure 15. Discharge hydrograph of Salmon River at Murray for 1969.

Included on the hydrograph plots are mean daily precipitation and temperature values which represent the average from data collected at the main Fraser Brook and Truro stations. Table 9 summarizes flow data of the Salmon River at Murray for a five year period. The hydrograph plot, together with the summarized flow data, illustrates some interesting relationships between runoff and rainfall.

The lowest mean daily flow was a discharge of 6.5 cfs (cubic feet per second) which occurred August 31st, 1969, while the highest flow, 4,110 cfs, occurred December 23, 1969. During individual years, however, maximum mean daily flows occurred during November, December, April and May, while the minimums all occurred in August.

If it is necessary to determine runoff past an ungauged point on a stream and runoff records are available at some other point on the stream, predictions of stream flow at the selected point can be made. This is best done by determining the mean volume of flow from the watershed in relation to a unit area. Using the mean total annual flow from the Salmon River above Murray (and a drainage area of 140 square miles), the volumes per unit area range from 3.5 to 6.4 (mean = 4.6) acre-ft. per day per square mile of drainage area. By using this figure, a crude estimate of daily flow can be determined at any point on the stream if the drainage area above that point is known. By using this method, a mean daily flow of about 700 acre-feet is expected under the Salmon River Bridge at Truro.

Fraser Brook Runoff

Stream flow records for Fraser Brook are complete for the years 1966-69 and the data summarized in Table 10. The minimum mean daily flow for this period was 0.02 cfs and occurred in August, 1966, while the maximum of 81 cfs occurred in December, 1969. The mean unit flow for the Fraser Brook watershed was 5.5 acre-feet per day per square mile during this four year period.

Figures 16 and 17 contain the mean daily discharge hydrograph of Fraser Brook and the average daily percipitation on the watershed during the water years, 1966 to 1969.

Table 10. Summary of discharge data of Fraser Brook, 1966 - 1969.

Year	1966	1967	1968	1969
Maximum daily discharge (cfs)	68 April 1	70 Oct. 11	65 March 14	81 Dec. 23
Minimum daily discharge (cfs)	0.02 Aug. 16	0.47 Aug.	0.03 Aug. 13	0.03 Aug. 31
Maximum monthly discharge (acre-ft)	993 March	1,800 May	1,380 March	1,180 Dec.
Minimum monthly discharge (acre-ft)	20 July	106 Nov.	36.8 Sept.	33 Aug.
Total discharge (acre-ft)	9,992	6,593	5,370	5,960
Unit flow (acre-ft) per day per sq. mi.	7.8	5.1	4.2	4.7

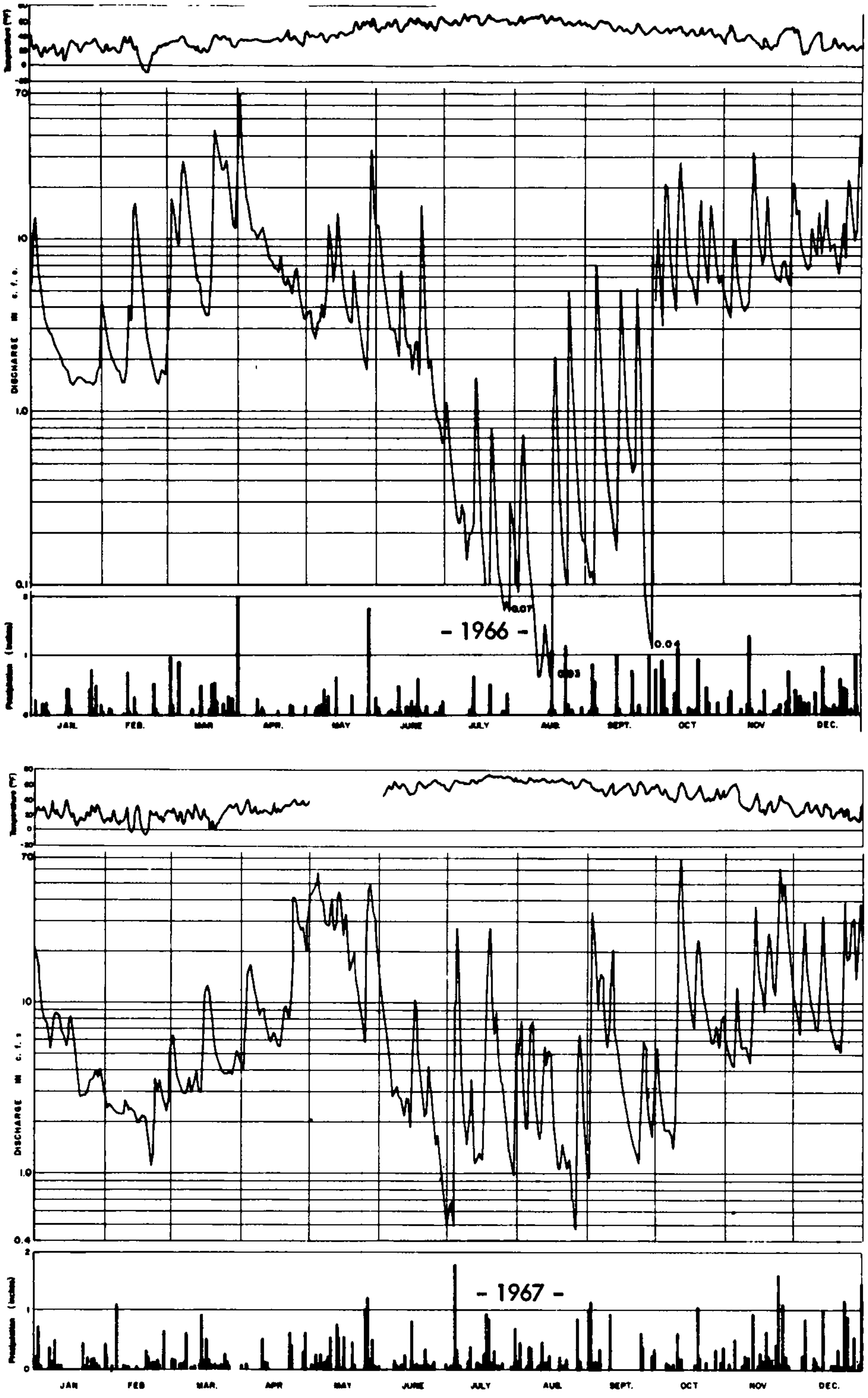


Figure 16. Discharge hydrographs of Fraser Brook for 1966 and 1967.

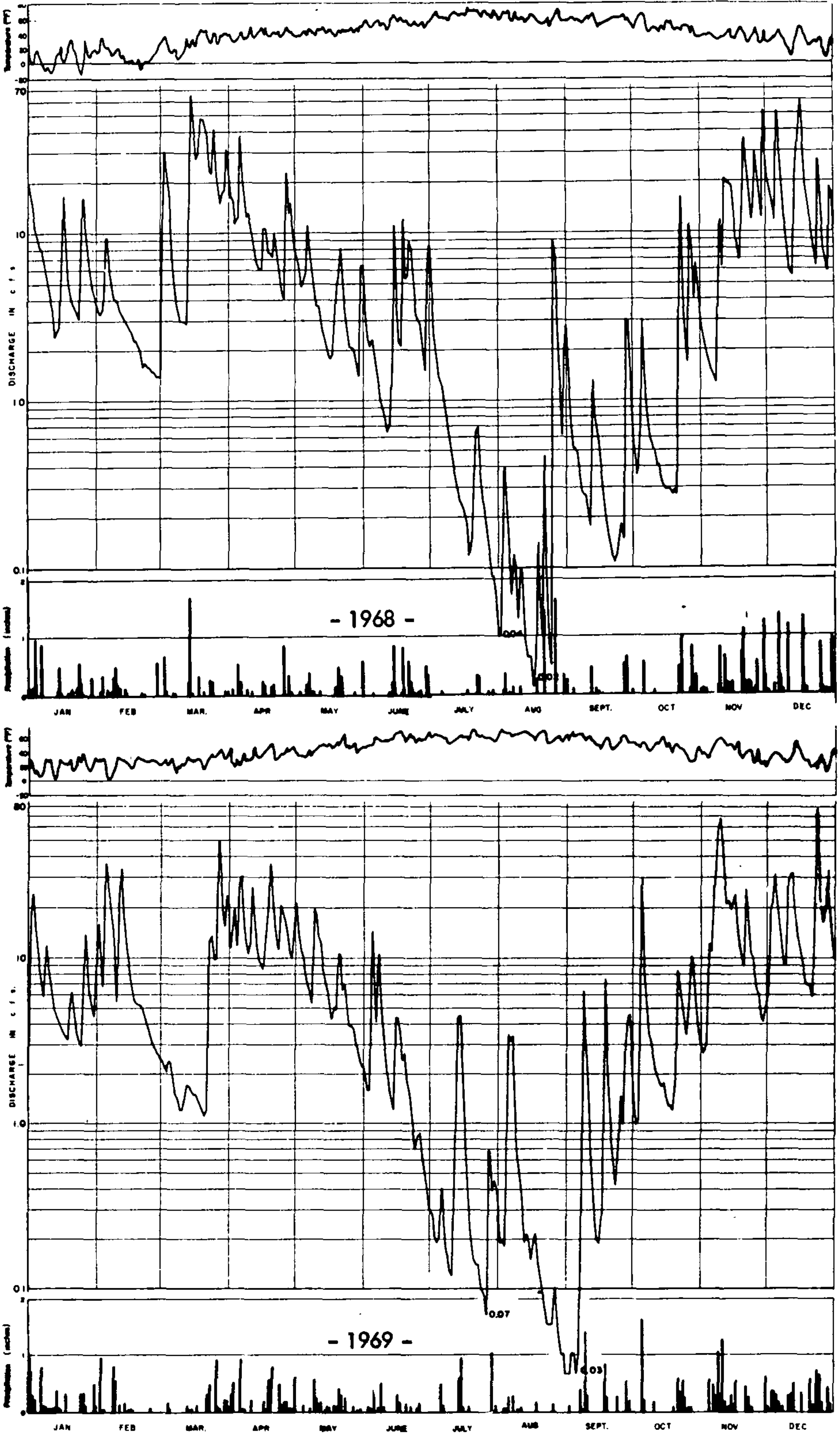


Figure 17. Discharge hydrographs of Fraser Brook for 1968 and 1969.

Runoff - Precipitation Ratios

A method offering a direct approach for determining an approximate hydrologic budget of a watershed is available when only precipitation and stream flow are known. The hydrologic equation, an inventory of the water balance of an area, is composed of elements which obviously vary widely from year to year, and of elements that are relatively constant. Some of the variable elements are so small that they can be considered insignificant when compared to the overall volumes.

An estimate of the amount of groundwater available in a watershed after losses due to evapotranspiration can be made if the hydrologic budget for the basin is computed.

Inflow or water gains to a basin are the elements on the left side of equation (2). In the Salmon River basin, all elements with the exception of P_r are considered negligible because they contribute little, if any, water to the basin.

On the right side of the equation, the elements may be classified into the two main groups of outflow and storage. Outflow elements include R, ET and U. An estimate of the mean U through the buried stream channel under Murray is about 0.4 cfs, which is a small fraction of the mean surface runoff at Murray. Therefore, the subsurface outflow from the watersheds under study is considered negligible and is disregarded in the budget computations.

The remaining elements on the right of the equation are various forms of water storage within a basin. Values for storage will be relatively the same at the end of each water year providing the past water year has not been an extremely wet or an extremely dry one. In the Beaverdam Creek Basin, Maryland, Rasmussen and Andreasen (1959) show that basin storage was only 3.2 per cent of the total precipitation, while the Pomperaug River Basin, Connecticut, Meinzer and Stearns (1929) found that basin storage was only 1.4 per cent of total precipitation, an average of 2.3 per cent.

In view of the facts that basin storage may account for only a small per cent of the precipitation and that runoff and evapotranspiration together account for possibly all but a few per cent of the precipitation, basin storage may be neglected for most purposes. To obtain a rough estimate of the budget for the years 1965 - 69 on the Salmon River watershed, only precipitation, runoff and evapotranspiration were used in the equation. Thus, knowing precipitation and runoff from available records, estimates of evapotranspiration were made by:

$$ET = P_r - R \qquad (6)$$

Table 11. Actual evapotranspiration losses from the Salmon River watershed during 1968.

	Hydrologic Budget	Adjusted Lake Evaporation	Freeze Program (1967)
inches of precipitation	13	17	21
% of precipitation	31	39	46

Table 12 summarizes the data for the budget determined for years 1965 to 1969. The average precipitation for the Salmon River basin was determined from data recorded at Fraser Brook and Truro. By solving equation (6), estimates of evapotranspiration for the period varied from 20 to 34 per cent of the precipitation for the Salmon River basin. A comparison can be drawn among the three methods of estimating evapotranspiration by referring to Table 11 which summarizes the data determined by the evaporation pan technique, application of the Holmes and Robertson (1960) method by use of the Freeze (1967) computer program, and the results of the hydrologic budget. Estimates of actual evapotranspiration for 1968 by the adjusted evaporation pan technique, indicated about 39 per cent of the precipitation lost while the Freeze program (1967) indicated about 46 per cent lost. Base flow in the Salmon River during 1968 accounted for 22 per cent of the total stream flow or 15 per cent of the precipitation, while total stream flow was equivalent to about 69 per cent, leaving 31 per cent of the precipitation lost as evapotranspiration.

Groundwater Hydrographs

Canso Group

Groundwater hydrographs showing the hydraulic head (fluid potential) existing in the Canso group at Fraser Brook is shown in Appendix F for the years 1966 - 1969 inclusive. Variations in the head are plotted against time, with temperature and precipitation also plotted to show their influence and correlative trends. Head fluctuations in the order of 3 feet occur in the Fraser Brook basin during a 12 month period. It is felt that this is a natural change because of the absence of any interfering large capacity pumping wells in that area.

The head changes resulting from precipitation show a very positive response with a short time lapse which would suggest a shallow flow system of the fracture type which is generally open and atmospheric. For example, the

Table 12. Hydrologic budgets for Salmon River watershed.

			Stream Flow								
	Precipitation		Direct Runoff			Base Flow			Evapotranspiration		
	inches*	acre-ft**	inches	acre-ft	% of precip	inches	acre-ft	% of precip	inches	acre-ft	% of precip
1965	30.3	226,000	19.5	145,590	64	4.2	31,500	14	6.6	48,910	22
1966	41.9	312,000	22.9	170,730	55	4.7	34,980	11	14.3	106,290	34
1967	53.6	400,000	29.6	220,780	55	13.5	101,040	25	10.5	78,180	20
1968	43.4	324,000	23.7	175,840	54	6.5	49,160	15	13.2	99,000	31
1969	46.1	344,000	29.7	220,200	64	3.8	28,950	8	12.6	94,850	28

* Inches of water over the entire basin.

** 1 acre-foot is the volume of water 1 foot deep over an area of one acre.

head in the well will peak within about 4 hours following the peak of precipitation. Also, the head response ratio of the flow system is in the order of about 0.1 ft. per 0.2 inch of precipitation. The nearly instantaneous change in hydraulic head in underlying artesian aquifers with river stage is a pressure response (Trescott, 1970). It is suggested that in fracture flow systems in discharge areas, i.e. the environment of the recorder well, that changes in river head would be transferred rapidly through the flow system, since such a system can also be confined. Also, the proximity of the well to the stream, in this case about 30 feet, could account for the nearly instantaneous response shown on the hydrographs.

An interesting semi diurnal fluctuation in the order of 0.04 ft. is observed in the hydrograph at Fraser Brook. Figure 18 shows a plot of this phenomena during a recession period when no dampening of the amplitude resulted from precipitation. The fluctuation is very regular, peaking early morning and early evening every day during all seasons of the year. It is suggested that this is either an effect of temperature variations and/or changes in barometric pressure.

Wolfville Formation

The hydrographs showing the hydraulic head existing in the Wolfville Formation at Bible Hill are shown in Appendix G for the years 1966 - 69 inclusive. Variations in head are plotted against time with temperature and precipitation also plotted. Changes in head over the period are in the order of 11 feet which may be partly due to groundwater withdrawals in that area.

Diurnal fluctuations in head (see Fig. 19) are believed to be the result of well interference of nearby deep wells used in the village. Lows are recorded in late evening followed by a period of recovery until about 6 a.m. when pumping caused another recession interval. It is also interesting to note that the rainfall recorded on September 27 (about 0.60 inch) had very little effect on the hydrograph, indicating that most of this water was used to satisfy the soil moisture deficit at that time, thus leaving a small portion of the water available for groundwater recharge.

Surficial Materials

The hydrographs shown in Figure 20 show the nature of and relationship between the recession and recovery of the groundwater and surface water stages in the floodplain at Murray. The three wells are drilled into the outwash deposits filling the buried channel under the floodplain. The graph shows a striking and consistent gradient of the water table towards the river. For example, there exists between well no. 190 and the river (a distance of about 800 feet) a head differential of about 5 feet, while the head differential in the

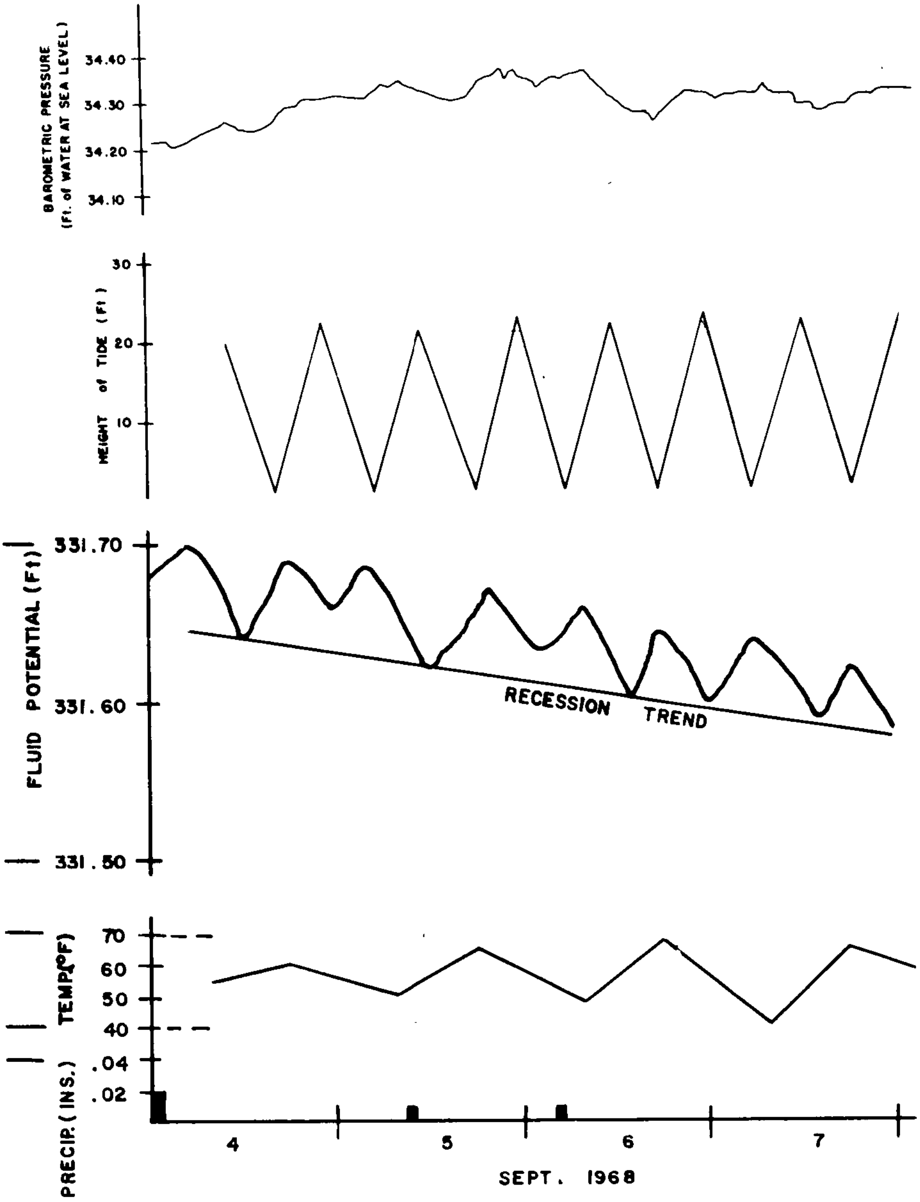


Figure 18. Semidiurnal fluctuations of fluid potential in the Canso Group at Fraser Brook.

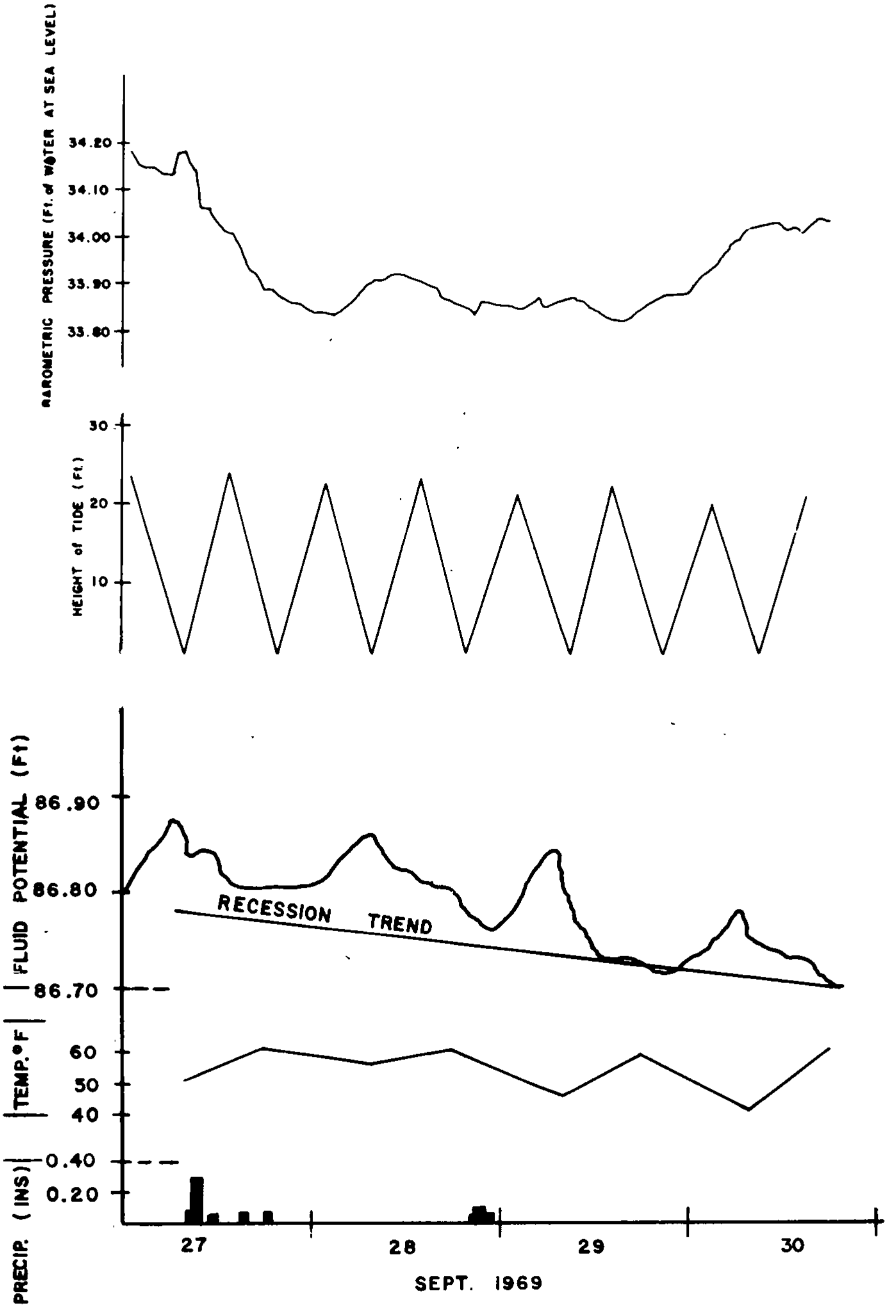


Figure 19. Diurnal fluctuations of fluid potential in Wolfville Formation at Bible Hill.

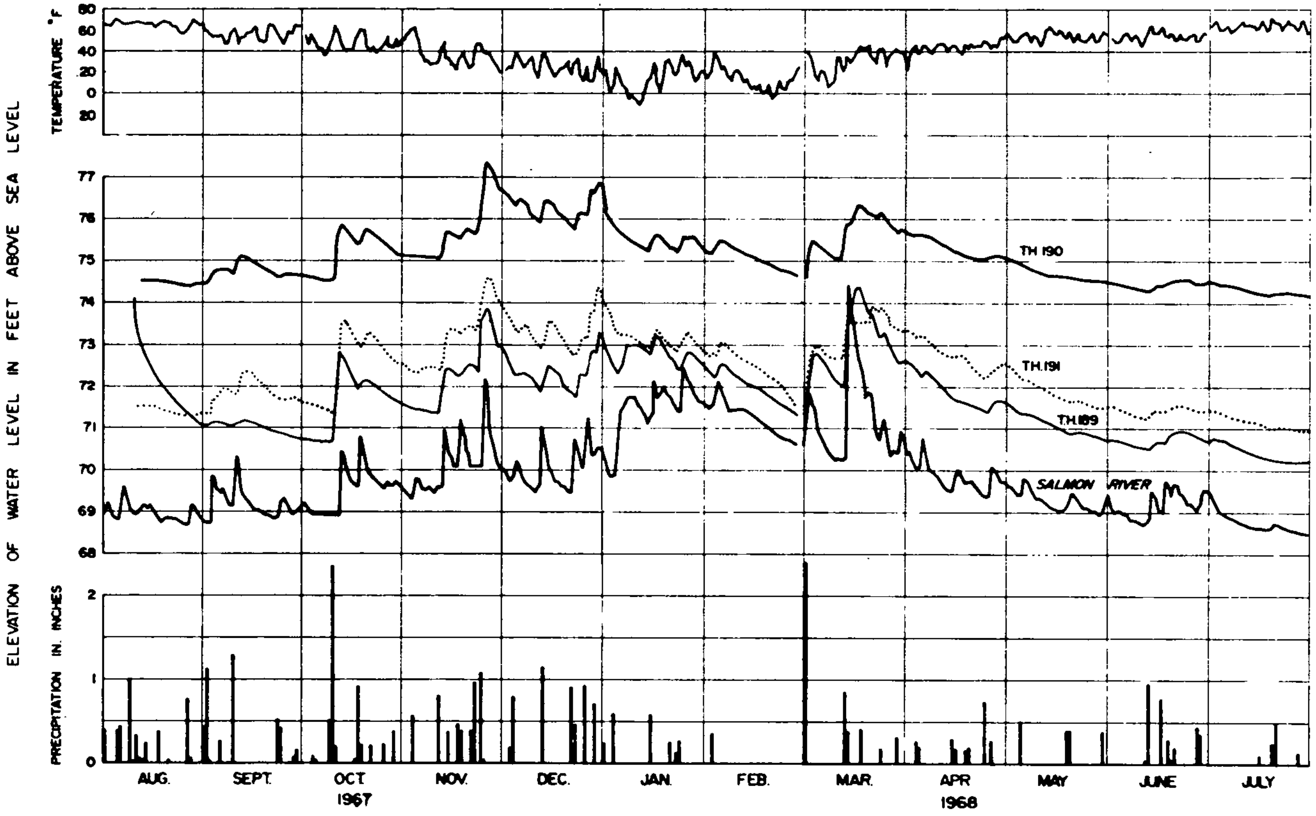


Figure 20. Groundwater and river stage hydrographs at Murray with pertinent temperature and precipitation data.

aquifer between the wells (spacing about 800 feet) varies between 1 and 3 feet. This represents a continuous contribution of base flow to the stream. However, the river response to precipitation and snow melt in March, 1968, indicates a reversal of the hydraulic head between the river and the floodplain deposits. During that short period, conditions existed which caused the river to be influent, and contributed water to the groundwater reservoir from the river channel.

Fluctuations in the head within the floodplain ranged about 3 feet over the one year period from August, 1967, to July, 1968. During the growing season, particularly June, July, August and September, there is much less head response in the groundwater table to precipitation because of the soil moisture deficit. It is not uncommon for such a deficit to exceed 2 inches. For example, a given amount of rainfall results in a much less contribution to the groundwater table in August than it does in November. In August, a greater portion of the rain goes to satisfy the soil moisture deficiency created by the heavy withdrawals by evapotranspiration.

HYDROSTRATIGRAPHIC UNITS

Introduction

A hydrostratigraphic unit is a group of geologic materials which have similar hydraulic and hydrochemical characteristics (Trescott, 1968). The hydraulic characteristics are expressed in terms of the water-storage and water transmitting properties, whereas the hydrochemical characteristics are expressed in terms of the chemical properties of water stored in and transmitted through such a unit. Several potentially productive hydrostratigraphic units exist in the map area which are not being utilized fully at present. The choice units are outwash sand and gravel deposits. These materials have favourable porosities and permeabilities for the storage and transmittance of large quantities of groundwater. Generally, both the porosity and permeability of unconsolidated earth materials are higher than those of indurated sediments or bedrock units. Thus, a unit thickness of these deposits is capable of storing and transmitting a larger volume of water than an equivalent thickness of bedrock materials.

Voids in rocks are classed as either primary or secondary. Primary or original voids found in sedimentary and igneous rocks were formed contemporaneously with the rock unit containing them. Their size and character are determined by the geological processes prevailing during formation of the rocks. Secondary voids, on the other hand, have resulted since the rock was formed. These voids are commonly described as joints, fractures, solution channels and fault zones. The significance of these features as water bearing zones depends primarily on their number, spacing and operature, all of which decrease with depth, because of the diminishing effects of weathering and increasing confining pressure of the overlying materials.

Porosity is the measure of the void volume of an earth material and is usually expressed as a percentage of the total volume of the mass. This value is also an index of how much groundwater can be stored in the saturated material which serves as an underground reservoir. The specific yield is the volume of water actually released from a unit volume of material when drained by gravity and is only a fraction of the porosity. It should also be noted that increasing the porosity of a material will not necessarily increase its permeability (one being a volume, the other a rate). Permeability is the rate of flow of a fluid through a unit cross section of a porous media under a unit hydraulic gradient, at a specific temperature. Sediments consisting of uniformly sorted gravels generally have the highest hydraulic characteristics. The porosities of these sediments are generally less than those of finer grained materials, whereas their specific yields are generally higher than those for finer and more poorly sorted sediments.

The coefficients of transmissibility and storage are commonly used in groundwater studies to express the water bearing characteristics of an aquifer. The coefficient of transmissibility (T) is the product of the field coefficient of permeability multiplied by the thickness of the saturated portion of the aquifer. Thus it is the rate of flow of water in gallons per day through a vertical strip of the aquifer 1 foot wide under unit hydraulic gradient (Ferris et al., 1962). In this report it has the units of imperial gallons per day per foot (igpd/ft.) The coefficient of storage (S) is the volume of water released from storage or taken into storage, per unit of surface area of the aquifer per unit change in head. In water-table aquifers, S is the same as the specific yield of the material dewatered during pumping (Johnson, 1966). Under artesian conditions where the piezometric surface is lowered by pumping, water is derived from storage by the compaction of the aquifer and its associated beds and by expansion of the water itself, while the interstices remain saturated (Walton, 1962).

The aquifers in the map area fall into the two main categories: confined and unconfined. A confined aquifer is one in which the movement of water is restricted above by an impervious or less pervious rock; when that rock is penetrated, the water level will rise above the level of the aquifer at that point. Thus a hydrostatic head or pressure exists in the aquifer. An unconfined aquifer is one in which the water is stored at atmospheric pressure and the hydraulic head (fluid potential) of the aquifer is equivalent to the elevation head at the well site.

The maximum safe pumping rates (Qs) indicated in this section were determined from data collected during pumping tests of at least 24 hours duration. Estimates of those rates are based on 20 years of continuous pumping which will at the end of that period result in utilization of 75% of the total available drawdown.

Bedrock Hydrostratigraphic Units

Cobequid Complex

The Cobequid Complex is composed of basically igneous and metamorphosed sedimentary rocks which are for all practical purposes too dense to yield much water. However, fracture systems within these rocks provide a means for storage and transmission of water through them. Generally the success of wells drilled into such rocks is marginal, producing barely enough for a domestic water supply which usually requires in the order of 1 igpm. However, such wells may occasionally be very productive. For example, Trescott (1969) reports two wells yielding 45 and 50 igpm; the former only 86 feet deep in granite, whereas the latter is 250 feet deep in slate.

Brandon (1963) indicates that in most places there is sufficient jointing in these rocks to yield 1 igpm in valleys, but at depths greater than 100 feet the joints may be too tight to yield any water. Table 13 lists a brief summary of data on 3 wells drilled into these rocks as reported by well drillers. Estimated yields based on 1 hour pumping tests vary from 2.5 to 7 igpm.

Lin (1970) found that the average well yield for 10 wells in slate was about 6 igpm, with yields ranging from 2 to 15 igpm. In quartzite and granite areas he reported an average of about 8 igpm, ranging from 1 to 26 igpm.

Table 13. Yield data on drilled wells in the Cobequid Complex*

Location	Well depth (ft.)	Depth to water (ft.)	Casing length (ft.)	Reported yield (igpm)	Water bearing rock
11E11A14	62	11	27	7	slate
11E11A26	90	20	30	4	slate
11E11A34	54	14	16	2.5	granite

*Summarized and interpreted from well drillers' records.

Horton Group

The Horton Group of rocks contains sandstone and conglomerate beds that can produce large amounts of groundwater in certain parts of the province. Wells penetrating these coarse-grained water bearing strata are reported to yield from 10 to 100 igpm (Trescott, 1968).

Brandon (1966) indicates that the Horton rocks of the Truro area may be expected to yield from 5 - 25 igpm to wells. Drillers' well logs from this group in the study area are limited, however the ones that have been located are listed in Appendix C. Table 14 summarizes 5 of these wells penetrating the Horton water bearing sediments. These logs indicate that the median yield is about 8 igpm (range from 3 to 15) from a median aquifer thickness of about 30 feet (range from 4 to 45 feet). Mean well yields based on these data should be in the order of about 35 igpm per 100 feet of saturated thickness of the water bearing rocks. However, this may vary considerably because of the distribution of numerous faults, especially in the western part of the map area.

Table 14. Summary of drillers' logs of wells drilled into the Horton Group

No.	Well depth (ft.)	Depth to water (ft.)	Casing length (ft.)	Reported yield (igpm)	Saturated thickness (ft.)
W7	76	4	31	8	45
W14	28		24	3	4
W15	40	3	10	15	30
W16	100		85	6	15
W52	50	12	19	8	31

Windsor Group

The secondary permeability in rocks of the Windsor Group probably accounts for all of the well yields that range from very low in the shales to very high in limestones and gypsum where solution channels occur. Such water bearing units are more likely to be encountered in the basal beds of the Windsor group, which consist of limestone and limestone conglomerate and which have been separated into the Macumber and Pembroke formations, respectively. However, the largest percentage of the Windsor group consists of shales, and it is not uncommon that drilled wells penetrating these units fail to yield enough water for domestic purposes. In several areas, for example, Upper Brookside, Shubenacadie, Glenholme, and Milford, wells drilled to depths of over 200 feet in soft clay and shale have been classed as dry holes. The incidence of dry holes in these clays and shales is higher than any other geological group with which the writer is familiar in Nova Scotia. Furthermore, rejection of water supplies that are obtained from these rocks is very common because of the high total dissolved solids (usually as calcium and sulphate). Consideration of both of these factors is usually enough to attempt development of other sources of water in such areas.

An illustration of how variable the water bearing properties of these rocks can be is shown by the yields of two wells drilled on the property of the Canada Cement Company near Brookfield, just south of the map area. One well drilled to a depth of 375 feet yielded about 250 igpm, while a second well, 900 feet away, 405 feet deep, yielded only about 10 igpm. The log of the second well indicates that the section consists of soft clay and shale. Although the log of the first hole is incomplete, it is suspected that limestone and/or gypsum beds are yielding a good deal of the water. A 48-hour pumping test conducted on the first well indicated a T of 1890 igpd/ft and an S of 3.2×10^{-4}.

Well (W31) listed in Appendix C drilled into the Windsor sediments in the area west of Hilden is reported yielding salt water.

Canso Group

Permeability in the Canso group of sediments is of the secondary type resulting from mainly fault planes and joint systems. The rocks consist mainly of well indurated sandstones and shales in which the original porosity has been practically eliminated through silicification and the process of compaction. As a result, the yields of wells drilled into this unit are generally small, varying from 5 to 25 igpm (Brandon, 1966).

Data obtained from a 24-hour pumping test conducted on an observation well at Fraser Brook indicated a transmissibility of about 350 igpd/ft. Based on this T value, the safe pumping rate is about 6 igpm. The saturated thickness of the formation penetrated was about 40 feet. Another well in the East Mountain area yielded about 8 igpm from 20 feet of section (W51, Appendix C).

As a result of the abundance and distribution of fractures in the Canso sediments in the map area, a high degree of confidence is placed in wells drilled into these units to produce enough groundwater for domestic uses.

Riversdale Group

The Riversdale group of sediments, which in the map area is bounded on both the north and south by faults, consists of mainly sandstones and shales. Well yields are sustained chiefly through fracture and fault systems. It is expected that well yields from these sediments would be similar to those found in the Canso rocks, because of a reduction in primary porosity through the compressional forces responsible for folding. Yields ranging from about 5 to 25 igpm should be expected.

Pictou Group

The Pictou group of rocks, consisting of shale, sandstone and conglomerate, yield water primarily through joints and bedding planes, although it is suspected that some flow is intergranular. In the map area, yields in the order of 5 to 25 igpm can be expected from these rocks. The yield from wells north of the Cobequid Mountains, where the sediments are less consolidated, may range from 10 to 75 igpm, the higher yields being from deep wells in low lying areas (Brandon, 1966). Well data is limited from this group in the study area. However, deep, high capacity wells drilled in the Amherst area are in the same group. Yields from these wells are estimated to be over 300 igpm. The well logs show that about 75 per cent of the saturated thickness in these wells is sandstone, mostly described as being soft. It is thus suggested that a good portion of the yield from these sandstones is intergranular flow.

Wolfville Formation

The clean, well sorted sediments of the Wolfville Formation provide the most productive bedrock hydrostratigraphic units in the map area. The water-bearing sandstone and conglomerate beds of this formation are usually confined by overlying beds of shale and/or siltstone, and wells drilled in the lowland area frequently encounter flowing conditions.

These sandstones and conglomerates are generally weakly cemented and loosely consolidated thus allowing the movement of water through intergranular pore spaces, with a smaller portion flowing through poorly developed joint systems and along bedding plane fractures. Strong evidence of the "softness" of the sandstone beds is indicated by the high incidence of well failure or collapsing under heavy pumping stresses of open wells.

Table 15 lists data obtained from pumping tests conducted on some of the larger municipal wells drilled into these rocks (see Appendix C for logs). The coefficient of transmissibility ranges from about 565 to over 14,600 igpd/ft. indicating that wells with between 200-300 feet of saturated thickness should yield at least 500 igpm for 20 years of continuous pumping. The economic significance of the transmissibility is clearly shown by comparing the yields of wells in the Debert and Truro areas. Both have the same safe pumping rate, but because of a higher T in the Debert area, only about 30 per cent of the drilling is required to give an equivalent well yield of that in the Truro area.

Siltstone and shale units of the Wolfville Formation yield much smaller amounts of water mainly through joints and bedding planes.

Table 15. Pumping test data from municipal wells drilled into the Wolfville Formation.

Location	Well depth (ft.)	Depth to water (ft.)	Transmissibility T (igpd/ft.)	Maximum safe pumping rate (igpm)
11 E 6 C 39 K Debert	150	21	14,600	600
11 E 6 D 12 B Bible Hill	145	40	2,490	90
11 E 6 B 97 O N.S.A.C.	300	63	3,600	300
11 E 6 B 99 K Truro	507	15	3,400	600
11 E 6 B 99 O Truro	382	9	565	80

Appendix C lists the logs of 29 wells drilled into the Wolfville Formation for domestic uses. Yields from these wells range from about 3 to 20 igpm, and average about 10 igpm (median also 10 igpm).

Stratigraphic data from test holes and wells drilled into these sediments are shown in Appendix B. Included in these diagrams are graphic logs, electric logs and penetration rates of wells drilled into the Wolfivlle Formation in the Truro area. The variable amounts of sandstone encountered in these holes is evident from the logs. For example, test hole no. 299 penetrated only about 6 per cent clean, well sorted sandstone, while nearly 34 per cent of the section was a poorly sorted silty sandstone.

Surficial Hydrostratigraphic Units

Glaciofluvial Deposits

The glaciofluvial deposits in the map area are by far the most productive water-bearing materials. For example, the transmissibility and storage coefficients of the outwash sands and gravels is in places 100 times greater than those of the best aquifers in the Wolfville Formation. Also, the storage coefficients of the sand and gravel materials often approach their specific yields.

Four areas in which some exploratory and pumping test data is available are Brookfield, Upper Onslow, Salmon River and the Town of Truro. Table 16 contains some of the pertinent data indicating the transmitting and storage characteristics of these aquifers (see Maps 1 and 2 for locations and more detail). Water analyses are also listed in Appendix D from all of these wells.

Table 16. Data obtained from screened wells drilled into sand and gravel deposits.

Well No.	Well depth (ft.)	Depth to water (ft.)	Storage Coefficient S.	Transmissibility T (igpd/ft.)	Maximum safe pumping rate (igpm)
W37	34	6	5.5×10^{-2}	2.9×10^{3}	400
W38	57	19	4.3×10^{-2}	7.5×10^{3}	400
TW368	30	9	8.7×10^{-2}	2.5×10^{3}	250
TW393	60	4	6.0×10^{-2}	3.5×10^{3}	2000
TW319	30	4	11.0×10^{-2}	51.4×10^{3}	300

Several other areas of glaciofluvial deposits occur that may warrant further exploration and evaluation of their water bearing potential. The outwash sand and gravel deposits along the Debert and Chiganois Rivers appear to offer excellent opportunities for developing groundwater by constructing shallow infiltration galleries. The materials are generally coarse gravels with good recharge potential from the respective rivers and should yield large quantities of water to properly designed and located screened wells.

The major limitations of these materials for producing large quantities of water will be factors which may impair the water quality. For example, because of present land use and the shallow nature of the water table, possible pollution hazards will have to be considered in development of such aquifers. Also, along the coastline where the fresh water lens is relatively thin, a very real danger exists in encountering and/or inducing saltwater.

Two well drillers' logs listed in Appendix C (W30, W32) indicate that the depth of overburden in the Hilden area is over 100 feet with sand and gravel deposits overlain by clay deposits. There are also several reported cases where flowing artesian conditions have been encountered in domestic wells penetrating confined sand and/or gravel deposits between Hilden and Truro. It should also be noted that the well yields reported in Appendix C are not indicative of the maximum that could be expected from these types of deposits. Such an evaluation would require installation and development of properly sized and placed well screens that will offer the optimum exposure of the water bearing zones and maximum utilization of the well screens' intake area.

CHEMICAL QUALITY OF GROUNDWATER

Introduction

The character and amount of chemical constituents found in groundwater depend mostly upon the geologic environment through which the water has passed and the time that the water has been in contact with this environment.

Hem (1959) indicates that the relationship between mineral composition of a natural water and that of the solid materials with which the water has been in contact may be comparatively simple for shallow unconfined aquifers recharged directly by precipitation. A complex relationship usually develops in confined or deeper interconnected aquifers where mixing of waters and continuing chemical reaction occurs.

The chemical composition of groundwater derived from the various hydrostratigraphic units varies greatly in the study area. However, the number of major dissolved constituents is quite limited and the natural variation is not as great as might be expected from the complexity of the geology.

The cations and anions commonly found in groundwater together with minor constituents are as follows (Todd, 1959, Table 7.1, p. 180):

Cations	Anions	Minor Constituents
Calcium (Ca)	Carbonate (CO_3)	Iron (Fe)
Magnesium (Mg)	Bicarbonate (HCO_3)	Aluminum (Al)
Sodium (Na)	Sulphate (SO_4)	Silica (SiO_2)
Potassium (K)	Chloride (Cl)	Boron (B)
	Nitrate (NO_3)	Fluoride (F)

The chemical analyses of groundwater samples collected in the Truro area are given in Appendix D. Also, the analyses of samples collected from the Salmon River are given in Appendix E.

The methods used to determine the amount of chemical constituents in the water samples were those outlined in "Standard Methods for the Examination of Water and Waste Water" (American Public Health Association, et al, 1965).

Analytical results are expressed as parts per million (ppm) and equivalents per million (epm). One ppm means one part by weight of dissolved matter in a million parts by weight of solution. The equivalents per million of an ion are determined by dividing the parts per million by the combining or equivalent weight of that ion (combining weight equals molecular weight of the ion divided by the ionic charge).

Test results for colour and turbidity are recorded in units of colour and turbidity. Hydrogen ion concentration is expressed in terms of pH value.

A *Piper trilinear diagram* (Fig. 21) is often used to classify water based on the dominant ions present. The values plotted are equivalents per million (epm) percentages of the more common anions and cations. The major cations are plotted in one triangular field; the major anions are plotted in the other; and the combined chemistry is plotted on the diamond-shaped field. Generally speaking from Fig. 21, the groundwater is quite strong calcium bicarbonate. However, there are areas where the water is strongly calcium sulphate, or sodium chloride. These areas will be discussed in the section on hydrostratigraphic units.

The simplest classification of water is based on the total concentration of dissolved solids as shown in Table 17 (after Davies and De Wiest, 1966, p. 118).

Table 17. Types of water based on total dissolved solids.

Name	Total Dissolved Solids (ppm)
Fresh Water	0 - 1,000
Brackish Water	1,000 - 10,000
Salty Water	10,000 - 100,000
Brine	Greater than 100,000

The suitability of a water supply depends entirely on its intended use and its quality and therefore, the quality criteria varies widely. As most groundwater pumped in the Truro area is for domestic use, the mandatory and recommended limits of the Canadian Drinking Water Standards (1968) should be met. These standards are summarized in Table 18.

The quality of groundwater in the Truro area is generally very good for most uses. The most common chemical constituents present which may be objectionable are total hardness, chloride, iron and/or manganese.

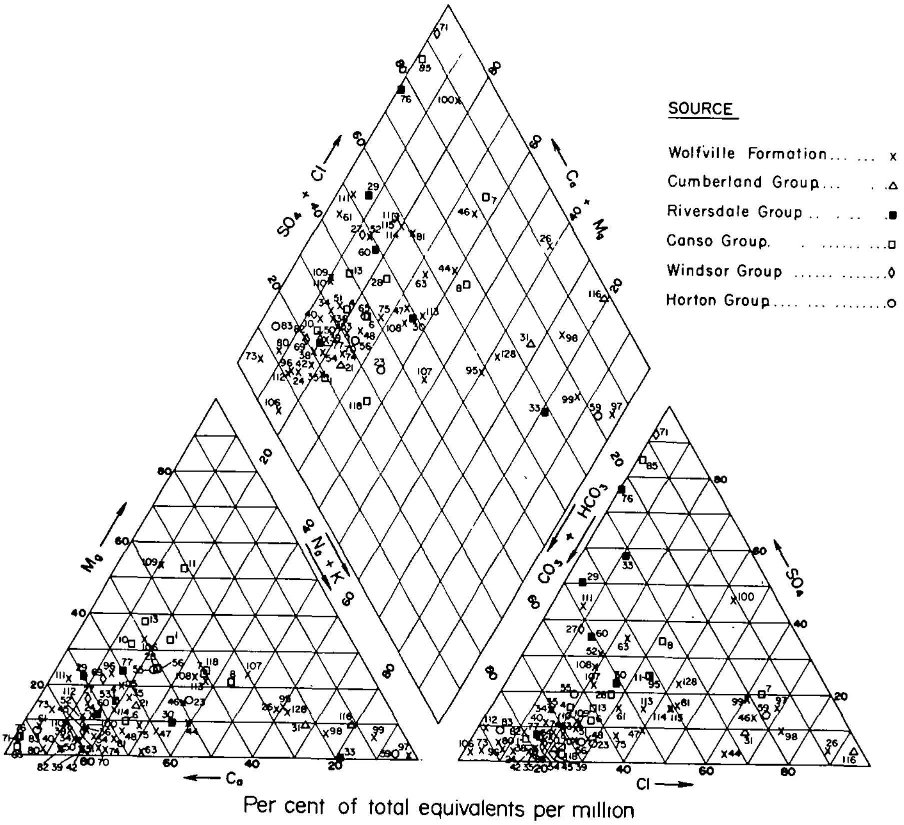


Figure 21. Trilinear plot of chemical analyses of groundwater samples collected in the study area.

The possibility of encountering salty groundwater is a threat in flat lowland areas near the coastline where the fresh water head is relatively small. Deterioration of groundwater quality can also be caused by high capacity wells constructed in such areas without consideration of the fresh water - salt water interface and the hydrogeology.

Table 18. Canadian Drinking Water Standards*

Chemical standards

Chemical constituents	Objective ppm	Acceptable limit ppm	Maximum permissable ppm
Chloride	<250	250	-
Copper	<0.01	1.0	-
Iron	<0.05	0.3	-
Lead	Not Detectable	0.05	0.05
Manganese	<0.01	0.05	-
Nitrate and Nitrite	<10.0	<10.0	-
Sulphate	<250	500	-
Total Dissolved Solids	<500	<1000	-
Zinc	<1.0	5.0	-

*Modified from "Canadian Drinking Water Standards and Objectives 1968" from the Department of National Health and Welfare, Canada, 1969.

Physical standards

Parameter	Objective	Acceptable limit
Turbidity	<1	5 (Jackson Turbidity Unit)
Colour	<5	15 (Platinum - Cobalt Scale)
Odour	0	4 (Threshold Odour Number)
Taste	inoffensive	inoffensive
pH	-	6.5 - 8.3

Relationship of Groundwater Quality To Use

Colour and Turbidity

Colour and turbidity are caused by the presence of organic and inorganic suspended material in water. The inorganic materials may be ferric oxide, fine sand, silt and suspensions of clay. Organic materials are either the result of bacterial organisms present or come from some soluble organic complexes. The colour is measured after the turbidity has been removed. It is usually caused by the presence of organic matter, industrial dyes and colloidal iron compounds.

Generally, the colour and turbidity values for water in the study area are below the limits outlined in Table 18. However, one sample collected from an abandoned well at West River Station had colour and turbidity readings of 350 and 320 respectively.

Iron and Manganese

Iron and manganese above certain levels are highly objectionable constituents in water supplies for either domestic or industrial use. Their behavior in water is chemically similar.

Iron imparts a brown colour, and manganese a black colour to laundry and containers and affects the taste of beverages, especially tea. When iron is present in amounts greater than 0.3 ppm, it gives a bitter, sweet, stringent taste to the water.

The recommended limits (see Table 18) for drinking water set by the Canadian Drinking Water Standards are: 0.3 ppm for iron; 0.05 ppm for manganese and 0.3 ppm for iron plus manganese.

Several of the groundwaters from different hydrostratigraphic units contain iron and manganese in concentrations greater than those recommended by these standards (see Appendix D). The highest reading of 19 ppm was in a sample from an abandoned well drilled into and possibly through the Cumberland Group at West River Station. Generally, the lowest values for Fe and Mn were reported for waters from the Wolfville Formation and the Horton Group.

Sodium and Chloride

Sodium and chloride ions found in water are usually associated with evaporite deposits. They also may be derived directly through salt water intrusion into a fresh water-bearing zone.

The suitability of an irrigation water is based mainly on the total dissolved solids, boron and sodium content.

The ratio of sodium to total cations is important because soil permeability is detrimentally affected by a high sodium ratio. The presence of sodium in drinking water supplies is also important to human pathology since certain diseases require water with low sodium concentration.

Table 19. Quality classification of water for irrigation.
(After Wilcox 1955)

Soluble sodium percentage	Calculated total dissolved solids (epm)	Water class
Less than 20	Less than 2.5	Excellent
20 - 40	2.5 - 7.5	Good
40 - 60	7.5 - 20.0	Permissable
60 - 80	20.0 - 30.0	Doubtful
More than 80	More than 30	Unsuitable

Two methods are available for determining whether the amount of sodium in a water is at a safe level for use of this water for irrigation purposes. In place of rigid limits of salinity for irrigation waters, quality is commonly expressed in these terms indicating a relative suitability (Table 19). The first method is a measure of soluble sodium percentage (SSP) and is defined by:

$$SSP = \frac{(Na + K)\ 100}{Ca + Mg + Na + K}$$

while the second method is a measure of the sodium absorption ratio (SAR) defined by:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

where all ions are expressed in epm. Richards (1954) proposed a recommended water classification for irrigation based only on SAR values.

High sodium values were recorded in samples from the Cumberland and Horton Groups, and in the Wolfville Formation at locations near the Cobequid Bay.

Chlorides in water may impart a salty taste at concentrations as low as 250 ppm when present with sodium, although in other waters where present with calcium and/or magnesium, 1000 ppm chloride may give a salty taste.

Chlorides also have detrimental effects when present in industrial and irrigation water supplies. McKee and Wolf (1963) suggest that the following concentrations of chloride will not be normally deleterious to the specified beneficial uses:

Industrial water supply ------------- 50 ppm
Irrigation ------------------------ 100 ppm

Several wells drilled in the west part of Truro have encountered water with high sodium chloride values (see analyses in Appendix D). Also, the chloride level has increased in the TAAC well, Town of Truro, from 33 to 77 ppm as a result of intermittent pumping over the past 20 years.

Nitrates

Nitrates are the end product of the aerobic stabilization of organic nitrogen and, as such, they occur in polluted waters that have undergone self-purification or aerobic treatment processes. Nitrates also occur in percolating groundwaters as a result of excessive application of fertilizer, or of leaching from cesspools. In excessive amounts, it contributes to the illness known as infant methaemoglobinemia, a disease causing certain specific blood changes resulting in cyanosis. The Canadian Drinking Water Standards (1968) set a limit of 10 ppm for nitrates mainly because of the danger to the health of infants in concentrations above this amount.

The presence of nitrates in industrial water supplies is injurious to the dyeing of wool and silk fabrics, and harmful to fermentation processes, causing a disagreeable taste in beer. Excess nitrates in irrigation waters tend to reduce soil permeability and they may accumulate to toxic concentrations in the soil. However, the presence of nitrates in irrigation water is often desirable because of their fertilizing value.

Most water containing high nitrate readings were samples from dug or shallow drilled wells, suggesting that the source is from barnyard or sewerage disposal systems. Also, the highest nitrate reading of 60 ppm was recorded in a sample from the water level observation well at Bible Hill (index no. 299) drilled to a depth of over 700 feet.

Sulphates

Sulphates occur naturally in water, mainly as a result of leaching from gypsum, and as the final oxidized stage of sulphides, e.g. iron sulphide. They may also be discharged in numerous industrial waste waters such as those from tanneries, sulphate-pulp mills, and other plants that use sulphates or sulphuric acid.

The presence of large amounts of magnesium sulphate ($MgSO_4$, epsom salt) and sodium sulphate (Na_2SO_4, glauber's salt) in drinking water often causes a laxative effect on persons unaccustomed to the water. The Canadian Drinking Water Standards (1968) recommend that sulphates do not exceed 250 ppm, except when a more suitable supply is not available.

Sulphates are generally less than the recommended limit in the Truro area. However, drilled wells into the Windsor and Riversdale Groups often encounter sulphate rich water. For example, a well at Hilden, containing 800 ppm sulphates, penetrates the Windsor sediments and a well at Onslow, containing 540 ppm sulphates, penetrates the Riversdale sediments.

Total Hardness

Hardness of water is caused principally by the elements calcium and magnesium and sometimes by iron, manganese, strontium and aluminum. Most of the calcium and magnesium present in natural water is in the form of carbonates (CO_3), bicarbonates (HCO_3), and sulphates (SO_4). When calcium and magnesium combine with the carbonate or bicarbonate in a water, a carbonate or temporary hardness results which may be removed by boiling. Permanent hardness or noncarbonate hardness cannot be removed by boiling and is caused principally by calcium sulphate but may include magnesium sulphate.

Because hardness of a water does not affect the health of people, there are no recommended upper limits for its occurrence in drinking water supplies. The major detrimental effect of hardness is economic; thus, if use of a hard water becomes sufficiently inconvenient, it may become more practical to either treat the hard water or to locate another water supply.

According to the U. S. Geological Survey's Classification (Swenson and Baldwin, 1965, p. 17), the hardness of water may be noted as follows:

Hardness (ppm)	
0 - 60	Soft
61 - 120	Moderately hard
121 - 180	Hard
More than 180	Very hard

Generally, groundwater in the map area is moderately hard. Groundwater from the surficial deposits is usually softer than the bedrock waters. Also, extremely hard water is encountered in areas underlain by the Windsor Group, where values over 1000 ppm are not uncommon.

Total Dissolved Solids (TDS)

Total dissolved solids in water include all solid material in solution. Thus, if all dissolved solids were determined by chemical analysis, the numerical sum of all these constituents would be equivalent to the total dissolved solids.

The Canadian Drinking Water Standards (1968) specify that the dissolved solids should not exceed 500 ppm if more suitable water is, or can be made, available. Higher concentrations than this limit in water may have a taste and may also have a laxative effect on new users.

Dissolved solids in industrial waters can cause foaming in boilers and interference with clearness, colour, or taste in many finished products. The recommended maximum concentrations in water supplies for industrial uses vary considerably with the type of industry.

Many of the TDS values were calculated from the specific conductance readings by the approximate relationship:

$$\text{TDS (ppm)} = \text{specific conductance } (\mu\text{mhos}) \times A$$

where A is an experimental constant generally ranging from 0.55 to 0.75 (Hem, 1970, p. 99). A higher value of A is usually associated with high sulphates.

The specific conductance (Spec. Cond.) is a measure of a water's capacity to convey an electric current. It is related to the total concentration of the ionized substances in water and the temperature at which the measurement was taken. The standard unit of electrical conductance, the mho, is used in reporting the Spec. Cond. of a water sample at a specified temperature. All Spec. Cond. analyses of this report are reported in mhos x 10^{-5} at 25°C.

Chemical Quality of Groundwater in the Hydrostratigraphic Units

Introduction

Groundwater samples collected in the Truro area were separated into groups according to the hydrostratographic unit which the well penetrated. Each group was further subdivided as to whether the samples were from a bedrock or a surficial source. A statistical analysis indicated that the total dissolved solids of water from the surficial materials is significantly less than the TDS of the bedrock units. No other generally distinguishable characteristic was noted to further separate these units. However, when considering the quality of water in the surficial materials, comparison with the quality of the underlying bedrock waters must be made with caution. The similarity or differences in quality will depend to a large extent on the part of the groundwater flow system penetrated as well as the relationship between the surficial materials and the underlying bedrock. The analyses listed in Appendix D are classified as bedrock or surficial samples. For purposes of comparison, sample No. 71 from a drilled well into the Windsor sediments has a total hardness of about 790 ppm, while No. 121 from a shallow screened well in surficial materials overlying the Windsor sediments and apparently isolated (hydrologically) from them has a hardness of only 53 ppm.

Horton Group

Groundwaters in the Horton sediments are typically calcium bicarbonate water of moderate hardness and total dissolved solids. These waters are generally slightly basic and low in iron. One sample from Hilden (Index No. 59) is classed as a sodium chloride water while all other samples have chloride values of less than 30 ppm. Generally, iron is not a problem either except in the Manganese Mines (East Mountain) areas where considerable iron and manganese mineralization is reported. The sodium chloride may possibly be attributed to remnants of the Windsor in the Hilden area, or to chloride pollution from road salt.

Windsor Group

Groundwater from the Windsor Group is generally of a very poor quality. The widespread occurrence of evaporite deposits in this group contributes excessive amounts of sulphates, hardness and total dissolved solids. Samples collected at Shubenacadie from the Windsor Group and from surficial materials overlying this group had as high as 2000 ppm total dissolved solids, mostly as calcium sulphate. As seen in the Piper diagram (Fig. 21), these waters are generally classed as calcium bicarbonate or calcium sulphate waters.

If a well penetrates only sandstones and/or shale beds of the Windsor Group, a water of fair to good quality may be encountered. Also, wells penetrating limestone and/or dolomite deposits could yield water of a quality suitable for most domestic purposes, although it may be classed as hard.

Canso Group

Groundwater from the Canso Group is generally calcium bicarbonate and of moderate hardness and total dissolved solids. The high calcium sulphate in a sample from East Mountain (Index No. 85) is probably a reflection of the geology. The well is drilled into fault zone adjacent to the Riversdale Group, and is structurally connected to the Windsor Group, both of which could be contributing the sulphates.

Analysis of two samples in the Camden area (Index Nos. 5 & 7) indicate low values of sodium chloride. However, the high sodium chloride ratios indicated in Figure 21 are probably caused by contamination from the application of road salt or from domestic septic systems.

Riversdale Group

The quality of groundwater from the Riversdale Group varies widely. Figure 21 indicates that it can be classed as a calcium, sulphate, bicarbonate water. High iron values were encountered in three of the six drilled wells sampled (see Appendix D). The average iron content of these samples was over 1.0 ppm. Hardness also varies from about 30 ppm to over 500 ppm (see Index No. 76) from wells drilled into this group of sediments. The average hardness for the drilled wells sampled is about 190 ppm.

Pictou Group

Groundwaters from the Pictou Group are typically calcium, sodium carbonate, chloride water. Total dissolved solids are generally low. Although the sample from West River Station (Index No. 116) contains over 2300 ppm sodium chloride, it is suggested that because of the well depth which is over 400, this may be the result of a structural influence by the Windsor Group. Stevenson (1959) states that sodium chloride does not normally occur in rocks of Pennsylvanian age and infers that any salt in these units originates in the underlying Windsor sediments. Iron is less than 0.3 ppm in all samples but No. 116, which is 19.0 ppm. Because of the corrosiveness of the water and the fact that the well has not been used for some time, this iron is probably dissolved from the casing. The log of the well is not available as it was drilled and immediately abandoned as a water supply over thirty years ago.

Wolfville Formation

Groundwaters from the Wolfville Formation are typically calcium bicarbonate waters. The several samples in Figure 21 showing a sodium chloride balance are usually wells drilled in the low lying areas near the sea shore. These wells probably penetrate the zone of diffusion or have induced the zone to move toward the well through heavy pumping. Iron is generally no problem.

Of the 65 samples collected, only four have iron present in amounts greater than 0.3 ppm. Hardness, occurring as mainly calcium bicarbonate or temporary hardness, ranges from about 50 ppm to 380 ppm.

Glaciofluvial Deposits

The quality of groundwaters in the surficial and glaciofluvial deposits varies from excellent to poor. Excellent quality water is obtained from shallow sand and gravel deposits where good sources of local recharge are available. Deeper sand and gravel deposits directly overlying the Windsor Group or those lying adjacent to the sea shore usually contain very high amounts of total dissolved solids and sodium chloride respectively.

A shallow screened well (Index No. 105) drilled at Brookfield yielded water with a hardness of about 53 ppm. This water bearing sand and gravel extends down to a depth of 30 feet where it is underlain by 50 feet of impervious clay material directly overlying the Windsor Group. The Little River provides a line source of recharge of soft water to the system.

Although there are several obvious and very significant advantages for developing these deposits for water supplies, there is also one very real danger. The closeness to the surface and the unconfined nature of many of these deposits renders them susceptible to pollution by sewerage outflows, petroleum spills and other chemicals disposed of in highly populated areas. Those situations require that the following three critical factors be considered when planning development of such supplies: (1) proper well location, (2) the implementation of sanitary construction techniques, and (3) land use planning.

SURFACE WATER QUALITY

Introduction

The general quality of surface water varies widely as a result of natural changes in flow, which affect the dilution factor, and man's activity, which usually upsets the natural chemical and bacteriological balance of the water system. Commonly untreated surface water is not as suitable for domestic and industrial purposes because of the varying and high values of colour, turbidity, temperature and bacteriological counts. Although the total dissolved solids in surface waters are normally less than in groundwaters, the variance of the above values place definite limitations on the use of untreated surface water.

Five sampling stations were established on the Salmon River and samples collected every two weeks during July to November 1967. The chemical analyses of these samples are listed in Appendix E. Locations of the sites are plotted on map No. 1 and map No. 2. A summary of the mean values at each site is shown in Table 20. Generally, an increase in most chemical constituents occurs in a downstream direction. However, turbidity decreases downstream from Riversdale.

Chemical Quality of Surface Water

Surface waters are classed as sodium, calcium and chloride waters from the plot on the Piper diagram, and are slightly acid. Although total dissolved solids and hardness are both low, they do vary significantly with river flow. Total dissolved solids estimated from the specific conductance are usually less than 75 ppm. The highest recorded is 88 ppm when the river stage was at its lowest flow (55.7 cfs) when sampled. Hardness is generally less than 20 ppm. A statistical comparison also showed that the general chemistry of the water is not significantly different among the five sampling sites. The most undesirable chemical qualities in surface water are iron, colour, turbidity and varying temperature.

Iron is ordinarily less than 0.3 ppm although locally it may be nearly twice this amount. The high readings at the Riversdale site can probably be attributed to the disposal of solid wastes into the river by that community. The highest reading at this site was 0.58 ppm when river stage was low. The average value of the twelve analyses is 0.36 ppm.

Table 20. Mean values* of chemical composition of Salmon River

Analyses in parts per million

Site	Fe	Mn	Cl	NO_3	Total Hard.	TDS	pH	Colour	Turb.
#89 Kemptown	0.18	0.01	5.96	T**	14.6	16	7.0	41	15.4
#88 Riversdale	0.36	0.02	6.88	T	11.3	16	6.7	84	21.4
#87 Union	0.23	0.01	12.2	T	17.7	43	7.1	43	13.3
#86 Murray	0.19	0.01	11.6	T	19.7	45	7.1	40	11.6

*Means of 12 samples
**T = concentration <0.01 ppm

Colour values varied from about 5 to over 100 units. The average colour at Riversdale was about 84 units, while at the other four sites, the means were about 40 units. Turbidity was also the highest at Riversdale where it averaged about 21 units. The mean values at the other sites were about 15 units. Turbidity values varied from about 2 to 70 units in the twelve samples from each site.

Surface water of good quality should be saturated with dissolved oxygen (DO) which is utilized by bacteria to biodegrade the organic material introduced to streams as sewerage and industrial wastes. The solubility of oxygen in water varies inversely with the temperature and directly with pressure and is somewhat reduced by the amount of dissolved solids present in the water (Hem, 1959, p. 144). Other factors that normally affect the DO levels of a river at a given point with a constant flow are (Department of National Health and Welfare, 1962):

(1) Fluctuations in the qualities of oxygen consuming wastes.
(2) Photosynthesis of water vegetation in sunlight.
(3) Re-oxygenation due to wind or turbulence.

At the time of sampling, the temperature and DO content were determined in the field. Temperature ranged from 70° F to 36° F (July to November). The DO level varied from about 9 ppm to about 17 ppm indicating complete saturation in all samples. At Union, a site located a short distance downstream from a rapids, several readings indicated a water supersaturated with oxygen.

Bacterial Quality of Surface Water

Several different groups of bacteria are found in water, and are mostly derived from contact with air, soil, living or decaying plants or animals, mineral sources and fecal excrement. Coliform organisms in water indicate fecal contamination, with which pathogenic, or disease producing, bacteria may be associated. Thus, the presence above a specified concentration of the coliform group of bacteria in water renders that water potentially unsatisfactory and of unsafe sanitary quality.

The coliform group of organisms includes, by definition, "all aerobic and faculative anaerobic, Gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas formation within 48 hours at 35° C" (McKee and Wolf, 1963, p. 308). This group includes organisms of many origins. The bacteriological examinations done for this study report the numbers of coliform bacteria present without regard to their origin, i.e. fecal or non-fecal. The effect of the coliform group generally is a basis for standards to make the water relatively safer. The Nova Scotia Department of Public Health use this group to indicate pollution of water with wastes and thus the suitability of a particular water supply for domestic and dietetic uses.

All bacterial examinations were carried out in the bacteriology laboratory at the Colchester Hospital by using the membrane filter technique. This technique allows the coliform colonies to be counted directly with the aid of a stereomicroscope. Results of a colony count are reported as the number of coliforms present in 100 mililiters (mls) of water.

The Nova Scotia Department of Public Health grade the water in 3 classes, A, B and C, depending on the number of coliforms present. Grade A water has a count less than 2 per 100 mls and is considered satisfactory for domestic consumption without disinfecting treatment. Grade B has a count between 2 and 10 per 100 mls of sample and is classed as doubtful for domestic consumption. Grade C water contains more than 10 coliform per 100 mls and is considered unsatisfactory for domestic consumption.

The sanitary quality of the Salmon River varies widely at points along its course and with time. Table 21 summarizes the bacteriological data collected during the sampling period. In general, the mean bacteria counts indicate a decrease in sanitary quality of the water in a downstream direction. The data also indicate that the water at the two upper sites, Kemptown and Riversdale, is of the highest sanitary quality on the river system. Above each of these sites, contamination contributed to the stream by domestic sewage is relatively small compared to that entering the stream below Murray.

Table 21. Coliform bacteria counts of samples taken from the Salmon River.

Site No.	Sampling Period	Median	Mean	Min.	Max.	% of Samples with a Count < the Mean
89	July - Nov. '67	29	35	0	150	58
88	July - Nov. '67	30	29	0	72	50
87	July - Nov. '67	27	48	12	140	66
86	July - Nov. '67	124	118	0	240	33
90	Nov. - '67	1735	1428	242	2000	25

The mean coliform count at site 86 is almost 250 per cent of that at site 87. Tributaries between these two sites receive water draining the Manganese Mines area, Valley and Murray areas, all of which contribute domestic sewage to the streams.

An increase in the mean values of coliform bacteria between site 86 (Murray) and site 90 (Truro) is over 1200 per cent. Site 90, which is subject to bacterial contamination from an increase in domestic sewage from the villages of Salmon River and Bible Hill, is also subject to polluting effluent from food processing plants and industry.

The bacteria count does not appear to be directly related to stream flow. This may be explained by a dilution factor and/or because there are areas where the greatest number of coliform bacteria is being continuously introduced to the stream at a specific point. Thus, below these points of influx the coliform density will vary inversely with the stream stage and directly with the coliform numbers in the effluent.

During periods of low river stage, only those sewage disposal systems discharging directly into streams will contribute sewage discharge to the river. On the other hand, after heavy rainfalls, surface runoff contributes coliforms derived from all sources; sewage disposal systems, open garbage pits, barnyards and pasture areas.

Table 22 shows the results of bacteriological examinations carried out on samples collected on December 13, 1967, when the river stage was at its peak. River discharge at Murray at this time was 1440 cfs., and the cleanest river with respect to sanitary quality was the North River which contained 184 coliforms per 100 mls. The highest coliform count, 1930 per 100 mls, was in the Salmon River sample taken just above the Salmon River Bridge at Truro.

Table 22. Coliform bacteria counts in samples from the various watersheds when stream discharge at Murray is 1440 cfs.

Sample No.	Area and Stream	Date Sampled	Coliform Bacteria Count per 100mls.
90	Truro (Salmon River)	13-12-67 9:50 a.m.	1930
91	Bible Hill (Farnham Brook)	13-12-67 10:15 a.m.	1530
92	Upper Onslow (North River)	13-12-67 10:30 a.m.	184
93	Upper Onslow (McCurdy Brook)	13-12-67 10:45 a.m.	770
94	Truro (McLure Brook)	13-12-67 11:45 a.m.	1450

UTILIZATION AND DEVELOPMENT

Introduction

Water supplies within the map area are presently derived from both groundwater and surface water reservoirs. Most domestic supplies in the rural areas are from groundwater, whereas the main municipal and industrial water demands are currently supplied from a central surface water system operated by the Town of Truro. This trend, which has developed over the years since the area became settled, has utilized a fairly adequate resource in the past. Although the present system is adequate to supply sufficient water to meet present demands, it is not sufficient to meet the expected demands to be placed upon it as a result of future expansion of the area. It is mainly because of these limitations of the surface system that careful consideration be given to developing the groundwater reservoirs available in the area. Abundant supplies of a good quality water may usually be obtained from drilled wells in the rural areas to supply the domestic and agricultural demands. The exploration programme carried out to date also indicates that the occurrence and type of water-bearing rocks within or near the Town of Truro are highly favourable for the withdrawal of large volumes of good quality groundwater.

Any future efforts to expand the water supply system of the Truro area to meet increased municipal and industrial demands will best be spent developing the relatively untapped groundwater reservoirs. The selection of groundwater rather than an alternative surface water supply at a considerable distance from the centre of consumption has definite advantages in this area (modified from Thomas, 1955):

(1) Groundwater is available in most areas of town convenient to consumers and to the main distribution system now operated by the town.

(2) The yield from wells would be relatively constant regardless of the season.

(3) The groundwater quality is not only more uniform with respect to temperature and dissolved solids, but is also of a much better sanitary quality and is free of colour and turbidity.

(4) The cost of developing the groundwater resources in this area will most likely be much less than the cost of impounding, treating and transporting surface water into the areas of demand.

Future groundwater exploration programmes may be confined to two main systems: the surficial deposit aquifers and the bedrock aquifers. Only a few small domestic supplies are derived from these unconsolidated sands and gravels by using well points or open casings. No large producing wells of this type exist in the area and there are only a few large capacity wells (withdrawing over 200 igpm) drilled into the bedrock aquifers. Of these wells, none has been evaluated thoroughly enough to indicate the maximum safe pumping rates which may be obtained from the wells or the interference that such pumping rates may have on neighbouring wells. Preliminary well testing has, however, indicated very high transmissibility values in both the surficial materials and the Wolfville Formation in certain areas.

The largest production wells presently being used are all drilled into the Wolfville Formation. Locations of these are at Debert, the Town of Truro and the Agricultural College at Bible Hill. Yield capacities of these wells vary from about 200 to over 600 igpm. However, the practical safe pumping rates are all about 200 igpm because of the porous and friable nature which render the water bearing formation subject to collapsing under high pumping stresses. Stabilization by screening and gravel packing is required in all such water wells before the optimum production of water from the wells can be obtained. Thus, good construction practice for wells in the Wolfville Formation is recommended if individual wells are planned to pump at rates greater than 200 igpm.

Domestic and Livestock Water Supplies

The commonly accepted value of water usage for domestic purposes is 100 U. S. gallons per day per person (Ameen, 1965). However, this figure varies considerably for metered and unmetered systems. The averages for the two types of systems vary from about 70 U. S. gpd for a metered service to about 250 U. S. gpd for an unmetered service.

Other institutional water consumption figures used in design for water requirements, also based on the population basis, are as follows (Ameen, 1965, p. 10):

Boarding schools, Elementary	75	U. S. gpd/person
Boarding schools, Senior	100	"
Clubs, country	25	"
Elementary schools	16	"
Hospitals	400	"
Junior & Senior High Schools	25	"
Rooming Houses	100	"
Summer Camps	60	"

Some typical figures on the amount of water necessary for certain home operations are as follows (Leopold and Langbein, 1960, p. 32):

Flush a toilet	3	U. S. gallons
Tub bath	30 - 40	"
Shower bath	20 - 30	"
Wash dishes	10	"
Run a washing machine	20 - 30	"

The average water requirements for livestock consumption have been estimated as follows (Anderson, 1963, p. 38):

Each horse	10	U. S. gallons per day
Each steer or dairy cow	12	"
Each milk-producing cow	25 - 30	"
Each hog	2	"
Each 100 chickens	4	"
Each sheep	1.5	"

Based on the above consumption estimates, a well capable of producing less than 1 gpm on a continuous basis, would provide an adequate water supply for a family of six. Also, a well capable of yielding about 3 gpm would be an adequate supply to the same family on a farm with a herd of 100 milk-producing cows. Such a minimum supply would only be practical with a proper pump that could utilize the total available drawdown in the well and sufficient storage to supply the peak demands. Ameen (1965) shows that hourly variations in water flow are greatest in small community water systems. Two periods of peak consumption occur daily; one at about mid morning, the other about 8:00 p.m.

It can reasonably be expected that a yield in the order of 1 to 3 igpm can be obtained from a drilled well nearly anywhere in the area. The number of reported cases where this yield has not been obtained are very rare. Wells drilled into the Windsor shales commonly fail to yield 1 gpm. Also, because of the relative broad lateral extent of these materials, a new location within a reasonable distance may not be any more promising. In other rock types that yield water through fracture systems (slates, quartzites, etc.), a productive well may often be drilled only a short distance from a well classed as a failure. In such areas that are known to be difficult, it is often more suitable to construct either a screened well in the surficial materials, if they are favourable, or a properly constructed dug well. With both types, it is imperative that proper precautions be taken to prevent surface pollution. The two most important considerations with this regard is well location and use of a grout material to divert surface and shallow drainage away from the well. Improper drainage usually results in bacteriological pollution from sewerage disposal systems, barnyards and other sources of pollutants. Proper well construction is particularly important in highly permeable surficial aquifers such as the glaciofluvial sand and gravel deposits in the more densely populated villages such as Brookfield, Salmon River and Debert.

Because of the extreme variability of groundwater chemical quality, the type of well construction should be considered before work begins. For example, the unsatisfactory water quality from drilled wells in areas underlain by the Windsor Group is a common problem. These waters are often unsuitable for domestic use because of the high sulphate and total dissolved solids content. In such areas, a shallow well developed in the overlying surficial materials will usually yield an adequate supply of good quality water.

For domestic purposes, the bacteriological quality of water is just as critical as the chemical quality. Pathogenic bacteria are not naturally present in groundwater unless introduced from a surface source. Therefore, for the best chance of obtaining a satisfactory water supply, careful consideration should be given to both the location and type of construction of the well.

The precautions outlined by the Department of Public Health and the regulation under the Well Drilling Act provide for proper protection of hand-dug wells, shallow screened wells and deep bedrock wells.

Irrigation Water Supplies

Irrigation is usually not practiced in the study area for agricultural crops. However, as the potential of the soils in this area is developed, the value of such a practice will then be realized. In the Debert and Masstown areas, a small amount of irrigation water is applied to cash crops of strawberries. It has also been shown that optimum soil moisture conditions can be maintained during some periods of the growing season only by supplemental irrigation. Most water used for irrigating at present is for watering lawns, greenhouse crops and small individual gardens and is included in the consumption figures under domestic and livestock supplies.

Water supplies for irrigation projects of larger commercial or agricultural crops may require wells with capacities of several hundred gallons per minute. In many areas, it is more practical to pump from a stream or lake source where the quality and quantity are suitable. The only areas where large quantities of a suitable quality irrigation water can be reliably obtained from wells are those underlain by the Wolfville Formation and/or the glaciofluvial sand and gravel deposits. In both materials screened wells should be constructed because of the heavy pumping stresses that tend to collapse the water bearing formations.

Municipal and Industrial Water Supplies

The Town of Truro operates a central water supply system which utilizes both surface water from Lepper Brook and groundwater from the Wolfville Formation. Several other systems, including those at Debert and the N. S. Agricultural College, depend entirely on groundwater obtained from wells drilled into the Wolfville Formation. This section outlines the potential for developing groundwater supplies to support future urban and industrial growth of some of the larger communities in the map area. Several areas, where common difficulties are encountered in obtaining suitable individual water supplies and protecting them from pollution, are considering the development of central groundwater sources.

Bible Hill

The incorporated village of Bible Hill lies on a ridge of Wolfville Formation between the North and Salmon River flood plains. Its location is excellent for developing groundwater sources from either the bedrock sandstones or from the outwash sand and gravel deposits associated with each river system. Census figures for the village show a population of 2901 (DBS 1966). Populations of the two main institutions, The Nova Scotia Youths Training Centre (250 students) and the Nova Scotia Agricultural College (600 resident students), are included in this figure. Based on the total population and domestic consumption, the daily water requirements for the village are about 290,000 gallons (200 igpm). Five industries in the village, Truro Raceway, Nova Scotia Provincial Exhibition, Coupar's Nursery Limited, Crowes Ice Limited and Domtar Chemicals Ltd., have their own water supply criteria. Domtar Chemicals Ltd., the biggest consumer, is presently supplied by the Town of Truro system and uses about 20 igpm (30,000 igpd metered consumption). The remaining industries are supplied solely by individual groundwater systems. Their combined estimated average consumption is about 25 igpm (36,000 igpd). The total capacity of the water storage facilities recommended by the Canadian Underwriters Association for the village, is 1,200,000 imperial gallons.

A supply of 300 igpm (430,000 igpd) should provide adequate water for the domestic, commercial and industrial demands of the village. However, because of the volume required for fire protection, the maximum demands on the system would be much greater than the average expected value. Horner (1970) estimates that the total maximum demand on the source will be as high as 1460 igpm, while the demand on the reservoir for fire protection is estimated at almost twice this figure.

The summary of test well data on Map No. 2 lists three bedrock wells in Bible Hill for which pumping test data are available. Wells W1 and W58 are presently used to supply the Agricultural College. Two other drilled wells at the College, for which there are no yield estimates, are also being pumped. The actual pumping rates of all four wells are unknown because of the lack of records. However, it is felt that none of the wells is being pumped at full capacity. The combined safe pumping rate of wells W1 and W58, based on 20 years of continuous pumping, is over 300 igpm.

Well W2 was drilled for a subdivision supply at the east end of the village. This 4 inch well, 145 feet deep, is capable of producing about 85 igpm. The high T of 2.3×10^3 igpd/ft. in this part of the Wolfville Formation is similar to that determined at the site of W1. If this well were reamed to a larger diameter and deepened to about 300 feet, it should produce a similar yield as W1. Wells penetrating sandstones in this formation can be expected to yield about 100 igpm for each 100 feet of saturated thickness.

It should be stressed, however, that the soft friable nature of the sandstones makes them subject to collapse under high pumping stresses. This problem is more common in such wells that are pumped at rates greater than 200 igpm. If a greater pumping rate is required from these wells, the formation should be stabilized by using well screens and gravel packs.

Another source for large quantities of groundwater is in the outwash sand and gravel deposits found in the buried stream channels of the North and Salmon River systems. Department of Mines test wells 368 and 393 were constructed in these materials and tested for yield and quality. The construction and pumping test data of these wells are listed in the summary of test well data on Map No. 2. Well 368 at Murray Siding, just outside the south east boundary of the village, was 30 feet deep and capable of producing about 250 igpm. Well 393 just outside the north west boundary of the village was 60 feet deep. The transmissibility of the formation at this site, based on the data from the 48 hour pumping test, is estimated to be about 1.6×10^5 igpd/ft. This is the highest value of T found in the map area. Based on this figure, a properly constructed well should yield up to about 2000 igpm.

At present, the water demands of the village are supplied by individually owned wells, most of which are drilled. Dug wells in the area have a history of going dry during summers when precipitation is below normal. In some cases, well points have been driven deep enough into the bottom of these wells to penetrate permeable sands below the lowered water table. In such cases, these points provide an adequate supply for domestic purposes. However, with a 2% increase in population per year (the highest in the map area) and the pollution problems associated with developing densely populated areas, a central water system would be a great asset to the village.

Brookfield

The village of Brookfield is located about 9 miles south from Truro. Census figures for the village show a population of 654 (DBS, 1966). Based on this figure, daily domestic water consumption for the village will be about 65,400 gallons (about 50 igpm). Estimated water requirements to satisfy the commercial demands is approximately 14,000 imperial gallons per day (about 10 igpm). In addition, a reservoir capacity of 100,000 imperial gallons is required to satisfy the recommendations of the Canadian Underwriters Association standard of Municipal Fire Protection (Horner, 1967).

The area is underlain by the Windsor Group of sediments. Surficial deposits consisting of stratified sand and gravel extend to depths of over 30 feet.

Test well No. 319, drilled into a shallow buried stream channel near the centre of the village, indicated favourable sand and gravel deposits for development of a well. As a result, a screened well was drilled to a depth of 30 feet. The 42 hour pumping test data collected indicated that the well was capable of producing about 300 igpm. The three observation wells used during the test also penetrated the aquifer. The mean values of T and S from the drawdown data in these wells were 51,400 igpd/ft. and 0.11 respectively. Water quality also was excellent. Two samples collected during the pumping test indicated an iron content of about 0.05 ppm and a total hardness of about 53 ppm.

Most water supplies in the village are from well points or dug wells which tap this or similar shallow aquifers. The few deep wells penetrate about 80 feet of surficial materials before encountering the Windsor sediments. The water supply is adequate from the shallow wells and quality is generally excellent. However, where improper well construction techniques have been used, or where a well has been poorly located, there have been reports of contamination, probably from septic tank effluent.

Wilma's Lake, a sinkhole in the Horton-Windsor contact in the east part of the village, is also used as a water supply. Residents near the lake and the South Colchester Regional High School use the lake as their source. However, this water requires chlorination because of the presence of coliform bacteria.

Another possible groundwater source for the village could be in the Horton sediments which lie northeast of the village. Any exploration in this area should be a safe distance, about 2000 feet east of the Windsor Group or Wilma's Lake. Wells developed closer to the Windsor sediments may reflect the water quality found in those rocks.

Other areas favourable for testing if additional groundwater is required include those locations where considerable depth of overburden was encountered. For example, about 4000 feet south of the centre of the village and on the west side of Little River, test hole No. 181 encountered gravel and clay to a depth of 60 feet before penetrating bedrock. Also, hole No. 125 in the centre of the village, indicated 60 feet of gravel and clay overburden.

Debert

The community of Debert, about 12 miles northwest of Truro, is ideally located for development of large supplies of groundwater. Aquifers in the area include the Wolfville Formation and extensive outwash sand and gravel deposits flanking the Debert River. The population of 726 (DBS, 1966) receive its domestic supply from individual wells constructed in both surficial and bedrock aquifers.

Two test holes (Nos. 130 and 132) were drilled into the outwash gravels (see map No. 1 for locations). Both holes encountered coarse and permeable gravel that could not be penetrated with a rotary drill using only drilling mud to support the formation. As a result, the total depth of these materials could not be determined. Test hole 132 did, however, penetrate 35 feet of the coarse gravel. That depth, with a high permeability and a saturated thickness of about 25 feet, could provide a large volume of groundwater through the construction of infiltration galleries and/or shallow screened wells.

Three wells drilled, each 10 inches in diameter, into the Wolfville Formation at Canadian Forces Base Debert, all encountered highly permeable water bearing sandstone and conglomerate beds. Records obtained from the Construction Engineering Section, C.F.B. Debert, indicate that well depths varied between about 130 and 150 feet. Pumping test data collected by L. V. Brandon of the Geological Survey of Canada at the time of drilling, indicated that the transmissibility of the sediments in each well was greater than 14,000 igpd/ft. The corresponding storage coefficient of each well was also in the order of 10^{-4}, indicating confined aquifer conditions. However, it is felt that estimates of safe pumping rates from these figures may be unreliable because of the low pumping rates and short duration of the test. Also, pumping at maximum rates indicated by the pumping test data would probably lead to collapse of the soft sandstones in the open wells. Because of these factors, the maximum permissable pumping rate indicated by the consultants evaluating the supplies was 160 igpm for each well. The reported production pumping rate has been 120 igpm each, about 75% of the maximum. To date, there have been no reports of sand entering the system.

Appendix D lists the chemical analyses of samples from two of these wells (see index Nos. 114 and 115). Generally, the water quality is excellent with a moderate calcium carbonate hardness and low total dissolved solids. Sample No. 115 does, however, show a localized high iron content of 4.7 ppm. Because two of the wells can produce an adequate supply, the third (No. 115) is used only as a standby source.

Hilden

Hilden is located about 4 miles south of Truro and has a population of about 656 (DBS, 1966). Water supplies in this village are obtained from individual drilled and dug wells. Several flowing artesian wells have been drilled in the low lying areas along McClures Brook. Existing well drillers' logs indicate yields can be expected in the order of about 35 igpm per 100 feet of saturated thickness from the underlying Horton sediments. Higher yields may be possible in areas where extensive fracturing has developed.

Surficial materials in the low lying areas may also be a good source for relatively large supplies of groundwater. Several drillers' logs indicate depths of these materials to be in the order of 100 feet. Screened wells constructed in sand or gravel beds contained in these deposits may yield large enough flows to satisfy industrial and/or municipal demands required for that area.

Salmon River

The community of Salmon River, with a population of 1219 (DBS, 1966), has the second largest annual percentage increase in population in the map area. The area is excellent for developing wells to produce large quantities of good quality groundwater. Salmon River is mainly underlain by rocks of the Wolfville Formation. In the extreme southern part of the community, older rocks of the Horton Group make contact with the younger sediments of the Wolfville Formation. In the northern part of the community, the Wolfville sediments are overlain with outwash sand and gravel deposits. These deposits occur as channel fillings, and depths of as much as 40 feet have been recorded in wells.

Part of the west side of the community obtains water from the Town of Truro water system. In the remainder of the area, individual dug and drilled wells are used to satisfy domestic and industrial water demands. Several well points have been driven into the outwash sand and gravels and provide adequate water supplies. In such cases along the river floodplain, the water table is encountered within 5 to 10 feet of the surface and fluctuates less than 5 feet annually. Thus, a well point driven only 20 feet into permeable sands or gravels should provide plenty of water for domestic purposes.

Test well No. 368 (see summary of test well data, Map 2), drilled just east of the village at Murray, penetrated 30 feet of these deposits. Data from a 72 hour pumping test indicated a transmissibility of 45,000 igpd/ft. and a storage coefficient of 0.087. Based on these data, a properly constructed screened well should produce over 200 igpm. The extensive nature of the deposits and the hydraulic connection with the Salmon River, present a very favourable condition for development of a well field consisting of many such individual wells. The proper positioning of infiltration galleries along the river is also a promising source of large volumes of groundwater. However, one of the biggest hazards of such a water supply is future land use of the area that would destroy the aquifer and/or impair the quality of water pumped from it.

Several wells drilled into the Wolfville Formation in Salmon River are listed in Appendix C. Two such wells are used for industrial purposes. The well (W13) drilled for the Meadow Vale Dairy is 123 feet deep and reported able to produce 40 igpm. Another well (W53) drilled to a depth of 191 feet for Producers Mild Products, is a flowing artesian well and is reported capable of yielding 30 igpm. The quality of this water is also excellent (see Index No. 106, Appendix D). Other logs listed in Appendix C indicate that wells drilled for domestic purposes are very seldom greater than 100 feet and commonly produce 10 igpm or more.

Truro

Truro is located in a favourable area for the development of large supplies of groundwater. Most of the town is underlain by the Wolfville Formation. A small area in the south part of the town is underlain by sediments of the Horton Group. Map No. 2 shows the distribution and thickness of glaciofluvial sand and gravel deposits within and near the town. Water consumption in the town averages about 1.5 million imperial gallons daily. It is estimated that the domestic demand averages about half, while the combined industrial and commercial demand accounts for the remaining 750,000 gallons per day. Thus, the population of 12,968 (DBS, 1971) use approximately 60 gallons per day per capita.

The town-owned utility operating the water system, uses both surface and groundwater to supply the demand. Lepper Brook, the surface water source, provides water of an inferior quality because of high colour and turbidity, and fluctuating iron levels, and temperature. The supply is also inadequate during dry periods. The quality and quantity of groundwater used to date have been consistent, but it is considered hard.

Four wells drilled in 1948 have been used to supplement the surface supply during periods of low stream flow. The available data on each well are listed in Appendix C (see W54, W55, W56 and W57). All are drilled into the Wolfville Formation. The deepest well (W54), the Salmon River well, is 400 feet deep and flows. Although no formal pumping test has been conducted on the well, it is estimated that the present pumping rate of 280 igpm is much less than the maximum safe pumping rate. The basis for this assumption is the small amount of drawdown (about 50 feet) resulting at that rate. From the pumping history and performance data available on the other three wells, the same estimate can be made regarding their maximum yield. However, the failure of W57 (Wood Street Well) indicates that under heavy pumping stresses, greater than 200 igpm, the soft friable sandstones tend to collapse, even when the amount of drawdown is relatively small. In such a formation, stability can be provided through installation of well screens and a gravel pack. The Wood Street well, although a sand producer from the beginning, was used for nearly 20 years on a part-time basis. It has not been used for the last few years because of the increasing percentage of sand produced.

Although each of the wells may be capable of producing much more water than is presently being pumped, they would require testing and pumping to determine: firstly, the depth and thickness of the water bearing zones in order to determine the length of screens; and secondly, the well interference and the effect pumping may have on the salt water - fresh water interface.

A new 10 inch diameter well (W59, Appendix C) was recently drilled to a depth of 507 feet in the west end of town encountering mostly sandstones, and produced a very good quality water. Pumping test data indicated a T of about 3400 igpd/ft. and an estimated yield of over 400 igpm. However, before this production rate is attempted, further pump testing should be carried out and observation wells used to help determine: (1) the storage coefficient of the aquifer; (2) the interference of other wells drilled into the same aquifer; (3) the stability of the soft friable sandstones under the resulting pumping stresses; (4) effects of pumping on the salt water - fresh water interface which is located a short distance west of this well site.

Large capacity wells can also be constructed in the glaciofluvial sand and gravel deposits shown on Map No. 2. These materials appear to be the most favourable in the centre, north and east parts of the town. They reach considerable depths (over 100 feet) in the west side, but their proximity to Cobequid Bay and the low topographic relief of the area may make pumping wells in such a location extremely susceptible to salt water intrusion.

Some preliminary investigation at Upper Onslow indicated that sands and gravels in the North River buried channel have a very high permeability and storage coefficient (see summary of test well data, Map No. 2). The data from test well 393, drilled to a depth of only 60 feet, indicated a high head and an average permeability of the materials of 3.5×10^2 igpd/ft.^{2}. These factors and the opportunity of using natural gravel pack screened wells tend to greatly reduce the cost of developing and supplying a source of groundwater from this type of an aquifer. Test wells in other areas indicated permeabilities of the same magnitude; however, the saturated thickness is not enough to make the wells as productive. A proper test drilling programme could possibly locate other areas where the thickness is enough to develop large capacity screened wells in areas closer to the town system.

SUMMARY AND CONCLUSIONS

Manufacturing, farming and lumbering are the main industries in the study area. Dairy farms, which dominate the agricultural economy of the area, are becoming larger, more efficient and fewer in number.

The soils developed over the Triassic, Windsor and Horton sediments and occupying the south and west quardrants of the study area, are the most suitable for agriculture. Soils overlying the Triassic sediments have the highest potential of productivity for a wide range of field crops with a small amount of difficulty. All other soils in the area have limitations that restrict the range of crops or require special conservation practices. Although the type of crop is somewhat limited by climatic conditions, a wide range of crops that are not frost-sensitive, such as most vegetables and forage crops, can be grown commercially in these soils.

Much of the study area is well suited for groundwater development. The Wolfville Formation underlies the west and central part of the area and contains many good sandstone and conglomerate aquifers. Within the limits of this formation (see Map No. 1) properly constructed wells may yield up to about 1 million imperial gallons per day depending on the well depth and the number of productive zones penetrated.

However, development of bedrock wells of this capacity are limited by three factors:

(1) the depth and areal extent of the cone of depression resulting from pumping of the Wolfville Formation will result in wider spacing of component wells in a well field.

(2) the chemical quality of water derived from the Wolfville Formation near Cobequid Bay may be somewhat inferior to that derived from the surficial deposits further inland and may also deteriorate with pumping.

(3) deep wells constructed in these sediments should be screened and gravel packed if pumping stresses greater than 200 igpm are placed on them.

Along the south shore of Cobequid Bay where the Wolfville Formation wedges out over the underlying Horton Group, the thickness of the sandstones and conglomerates may not be enough to yield large amounts of groundwater. Also, locations where these sediments are thick in that area would be very close to the Bay and may be susceptible to salt water intrusion. Along the northern limits where the Wolfville Formation makes a faulted contact with the older Pennsylvanian sediments, their thickness should not be affected because of the near vertical attitude of the fault. Wells located very near the contact, however, may show a negative boundary effect under pumping because of the generally lower permeability of the older sediments.

In the north half of the study area, rocks of Pennsylvanian age normally produce both good quality and relatively large amounts of water. Many of these rocks are semi-consolidated sandstones which have a significant primary permeability. The occurrence of joints, faults, etc. in these sediments also results in local areas of high permeability even in the finer grained sediments. Although there have been no recorded attempts to construct large capacity wells in these sediments within the study area, in neighbouring areas yields of wells drilled into the same group of rocks indicate that wells with several hundred feet of saturated thickness should yield over 100 igpm.

The Mississippian rocks in the south part of the study area have highly variable water bearing potential. The Horton Group of sediments yield water mainly through fractures. Wells with several hundred feet of saturated section should yield over 25 igpm. Water quality is generally very good. However, in areas where these sediments are structurally and/or hydraulically connected with the Windsor sediments, the water quality will be affected and will also deteriorate with pumping. Wells drilled in the soft Windsor shales commonly fail to yield enough water for domestic purposes. If wells drilled in the Windsor Group penetrate limestone and/or gypsum beds, yields of over 100 igpm may be expected, depending on the depth of the well and the number and thickness of these permeable zones. The water quality from such wells will place definite limitations on its uses because of the normally high calcium and sulphate content.

The surficial deposits within the study area offer a good means through which precipitation may infiltrate and enter the groundwater reservoir system. Over 50 per cent of the area is covered with granular materials which allow a high rate of recharge to the aquifers within the surficial deposits. The most promising of these shallow sand and gravel aquifers occur adjacent to the Debert, North and Salmon Rivers. In this area of central Nova Scotia, the present and projected increase in water demand is greatest as the result of industrial and population growth.

The saturated thickness of sand and gravel deposits in the immediate area of the Town of Truro is shown in Map No. 2. The main areas of interest along the North and Salmon Rivers are shown on this map. Only limited water supplies can be developed where the saturated thickness is between 0 and 20 feet. This is especially so in parts of the Town of Truro where fine sands interbedded with coarser sands and gravels reduce the permeability to a point where yields of between 50 and 100 igpm can be expected from shallow screened wells. In other areas where the coarser sediments are hydraulically connected to the river, infiltration galleries or well point systems may be constructed to yield several hundred igpm. The design of galleries and optimum spacing of well points can only be determined by test drilling and pumping tests.

In areas where the saturated sand and gravel is greater than 20 feet thick, the possibility of using surficial aquifers should definitely be explored. If the local surficial aquifers prove to be unsatisfactory, in most areas wells drilled into the underlying bedrock should yield at least enough for domestic purposes. In bedrock depressions where the saturated thickness of sand and gravel is greater than 60 feet, the best, largest and most economical water supplies will probably be in the surficial materials. In the North River buried channel, for example, data from a test well 60 feet deep in saturated gravel indicated a safe pumping rate of about 2000 igpm. When exploring for large capacity wells, several test holes should be drilled because of the variable nature of these deposits.

Although there is an abundant quantity of surface water in the area, its chemical and sanitary quality renders it less suitable for most uses without treatment. The presence of large numbers of coliform bacteria makes this water unsafe for domestic use without disinfection. This is particularly true of the Salmon River below Murray, where the sanitary quality deteriorates very rapidly. Also, the presence of high colour and turbidity restricts the uses of raw water for industrial purposes.

The hydrologic budgets for the Salmon River watershed for the water years 1965 - 1969 showed that about 73% of the precipitation appears as stream runoff; the remaining 27% is lost as evapotranspiration. Determinations based on the cutoff line method indicated that about 15% of the precipitation appears as base flow.

Nonuniform amounts of precipitation were recorded in a network of 16 rain gauges instrumented throughout the study area. Values of the coefficient of variation among the sites were as high as 63%.

REFERENCES

Ameen, Joseph, S., 1965, Community Water Systems Source Book; 3rd edition, Technical Proceedings, P. O. Box 5041, High Point, N. C. 27262, 218 p.

American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1965, Standard methods for the examination of water and waste water, 12th ed., American Public Health Association Inc., New York, 769 p.

American Water Resources Association, 1967, Proceedings of the national symposium on ground-water hydrology; P.D.Q. printing service, Urbana, Illinois, proceedings series No. 4, 365 p.

Anderson, K. E. (ed), 1965, Water Well Handbook: Missouri Water Well Drillers Association, 281 p.

Bell, W. A., 1929, Horton - Windsor District, Nova Scotia; Geol. Survey of Canada, Mem. 155, 268 p.

__________, 1958, Possibilities for occurrence of petroleum reservoirs in Nova Scotia, N. S. Dept. of Mines, 177 p.

__________, 1960, Mississippian Horton Group of type Windsor - Horton district, Nova Scotia, Geol. Survey of Canada, Mem. 314, 112 p.

Boulton, N. S., 1954, The drawdown in the water-table under unsteady conditions near an unconfined formation; Proc. (British) Inst. Civil Engrs., V. 3, Pt. 3.

Butler, S. S., 1957, Engineering hydrology; Prentice Hall, Englewood Cliffs, N. J., 356 p.

California State Water Pollution Control Board, 1954, Report on the investigations of travel of pollution: Publication No. 11, 218 p.

Chapman, L. J., and D. M. Brown, 1966, The Canada Land Inventory, Canada Dept. of Forestry and Rural Development, Report No. 3, 24 p.

Clark, J. W., and W. Viessman, 1965, Water supply and pollution control; International Textbook Co., Scranton, Pennsylvania, 575 p.

Davis, S. N., and R. H. M. De Wiest, 1967, Hydrogeology: John Wiley and Sons, Inc., New York, 463 p.

Dawson, J. W., 1855, Acadian Geology: London, 1st. Ed., 833 p.

Department of National Health and Welfare, 1962a, Aspects of pollution, Cornwallis River, Nova Scotia: A survey report, 53 p.

________________________________, 1962b, Aspects of pollution, Annapolis River, Nova Scotia, A survey report, 72 p.

Flint, R. F., 1963, Glacial and pleistocene geology: John Wiley and Sons, Inc., 533 p.

Freund, J. E., 1965, Modern elementary statistics: Prentice - Hall, Inc., 413 p.

Goldthwait, J. W., 1924, Physiography of Nova Scotia: Geol. Survey of Canada, Mem. 140, 178 p.

Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water: U. S. Geol. Survey Water-Supply Paper 1473, 363 p.

Hogg, W. A., 1953, Pleistocene geology of Pictou County, Nova Scotia: unpublished report, 50 p.

Horner, W. N. and Associates, 1967, Feasibility study water system sanitary sewage collection and treatment system, Village of Brookfield, Nova Scotia, unpublished report, 18 p.

________________________, 1970, Engineering feasibility study for a water supply system village of Bible Hill, Colchester County, Nova Scotia, unpublished report, 41 p.

Johnson, E. E., Inc., 1966, Groundwater and wells: 1st. ed., Edward E. Johnson, Inc., Saint Paul, Minnesota, 440 p.

Jones, J. F., 1963, Aquifer-test procedures and other information used in evaluating groundwater supplies in Alberta, Preliminary Report 63-1, 35 p.

__________, 1966, Geology and groundwater resources of the Peace River District, Northwestern Alberta, Research Council of Alberta, Bulletin 16, 143 p.

__________, (ed.), 1967, Nova Scotia Water Resources Study; a compilation of existing data: Atlantic Development Board.

Klein, G. DeV., 1962, Triassic sedimentation, Maritime Provinces, Canada: Geol. Soc. Am. Bull., v. 73, no. 9, p. 1127 - 1146.

Lin, Chang L., 1970, Hydrogeology of the Musquodoboit River Valley, Nova Scotia, N. S. Dept. of Mines, Report No. 70-3, 60 p.

Linsley, R. K. and J. B. Franzini, 1964, Water resources engineering: McGraw-Hill Book Company, New York, 654 p.

McGuinness, C. L., 1963, The role of groundwater in the national water situations: U. S. Geol. Survey, Geol. Survey Water-Supply paper 1800, 1121 p.

McKee, J. E., and Wolfe, H. W., (ed.), 1963, Water quality criteria: The Resources Agency of California, State Water Quality Control Board Pub. No. 3-A.

Meinzer, O. E., 1923, The occurrence of groundwater in the United States: U. S. Geol. Survey Water-Supply paper, 489, 321 p.

Moroney, M. J., 1951, Facts from figures: Penquin Books Ltd., 472 p.

Nova Scotia Department of Development, 1970, County Surveys.

Nova Scotia Department of Trade and Industry, 1964, Colchester county survey.

____________________________________, 1965, Nova Scotia, an economic profile: Econ. Services Division, V. 4, 71 p.

Peck, R. B., Hanson W. E., and Thornburn, T. H., 1966, Foundation engineering: John Wiley and Sons, Inc., 410 p.

Powers, S., 1961, The Acadian Triassic Jour. Geol., V. 24, p. 1-26, 105-122, 254-268.

Prest, V. K. and D. R. Grant, 1969, Retreat of the Last Ice Sheet from The Maritime Provinces -- Gulf of St. Lawrence Region: Geol. Sur. of Canada, Paper 69-33, 15 p.

Ramussen, W. C., and Andreasen, G. E., 1959, Hydrologic budget of the Beaverdam Creek Basin, Maryland, U. S. Geol. Survey Water-Supply Paper 1472, 106 p.

Richards, L. A., (ed.), 1954, Diagnosis and improvement of saline and alkaline soils: U. S. Dept. of Agriculture Handbook no. 60, 160 pp.

Schicht, R. J. and Walton, W. C., 1961, Hydrologic budget for three small watersheds in Illinois: Ill. St. Water Survey, Rept. of investigation 40, 40 p.

Steel, R. G. D., and Torrie, J. H., 1960, Principles and procedures in statistics: McGraw-Hill Book Company, Inc., 481 p.

Stevenson, I. M., 1958, Truro map area, Colchester and Hants counties, Nova Scotia Geol. Survey Can., Mem. 297, 124 p.

Thomas, H. E., 1955, Underground sources of our water, in Water; the U. S. Gov. Print. Office, U. S. Dept. of Agriculture, No. 32.

Thomas, J. F. T., and Gale, R. M., 1965, The Upper Great Lakes Drainage Basin in Canada, 1957-63: Dept. of Mines and Technical Surveys, Water Survey Report No. 14, 137 p.

Thomas, M. P., 1966, Effect of glacial geology upon the time distribution of stream-flow on eastern and southern Connecticut: U. S. Geol. Survey Prof. paper 550-B, pages B209 - B212.

Thorne, D. W., and H. D. Peterson, 1954, Irrigated soils: 2nd ed., The Blaidistan Company, Inc., New York, 392 p.

Thwaites, F. T., 1957, Outline of glacial geology: Edwards Brothers, Inc., 136 p.

Todd, O. K., 1959, Groundwater Hydrology; John Wiley and Sons, Inc., New York, 336 p.

Toth, J., 1962, A theory of groundwater motion in small drainage basins in central Alberta, Canada; Jour. Geophys. Research, V. 67, p. 4375 - 4387.

Trescott, P. C., 1967, An investigation of the groundwater resources of the Annapolis-Cornwallis Valley, Nova Scotia: Univ. of Ill. PhD Thesis, 269 p.

____________, 1970, Piezometer Nests and Groundwater Flow System near Berwick, Nova Scotia; N. S. Dept. of Mines, Report No. 70-1, 29 p.

__________, 1969, Groundwater Resources and Hydrogeology of the Windsor-Hantsport Walton Areas, Nova Scotia, Report No. 69-2, 58 p.

__________, 1968, Groundwater Resources and Hydrogeology of the Annapolis-Cornwallis Valley, Nova Scotia; N. S. Dept. of Mines, Mem. 6, 159 p.

Turner, J. A., 1958, A simplified scheme for computing Thornthwaite's potential evaporation: Canada Dept. of Transport, Met. Branch, Cir-3118, Tec-284, 12 p.

United States Dept. of Agriculture, 1955, Water: The United States Government Printing Office, No. 32, 751 p.

United States Public Health Service, 1962, Drinking water standards: Publication No. 956, 61 p.

Walton, W. C., 1962, Selected analytical methods for well and aquifer evaluation: St. of Ill., Dept. of Registration and Ed., Bulletin 49, 81 p.

Weeks, L. J., 1948, Londonderry and Bass River map areas, Colchester and Hants Counties, Nova Scotia, Geol. Survey of Canada, Mem. 245, 86 p.

Wicklund, R. E., and Smith, G. R., 1948, Soil survey of Colchester County, Nova Scotia: Dominion Dept. of Agriculture, Report No. 3, 57 p.

APPENDIX C

Selected Logs of Water Wells in Standard Topographic Map Sheet 11 E 6

Well drillers' logs given in this appendix are mostly those which include a lithologic log and/or drawdown data on a pumping or bail test. These wells have been located in the field and are shown on map No. 2. The lithologic logs have been used as an aid in mapping the surficial geology and determining the depths used for the isopachs shown on map No. 2. In some cases, the wells also provided rock samples for geological analyses and water samples, of which the chemical analyses provided very useful data which help to contribute to a better understanding of the groundwater resources of the area.

The following abbreviations are used in the table:

Driller:

6	Hub Well Drilling Company
15	Hingley Well Drilling
36	Samuel A. Messervey
10	Lawrence Baird
18	S. G. Trask and Sons Ltd.

Use:

D = Domestic
P = Public
I = Industrial

Pump or Bail Test:

igpm	imperial gallons per minute
DD	drawdown
REC	recovered to

Lithologic Log:

cl	clay
sd	sand
gr	gravel
sh	shale
ss	sandstone
bldrs	boulders
sl	slate
congl	conglomerate

APPENDIX C. SELECTED LOGS OF WATER WELLS IN STANDARD TOPOGRAPHIC MAP SHEET 11 E 6

No.	Cl.	M.T.	Map	Owner	Driller Lic. No.	Well Depth (ft.)	Water Depth (ft.)	Hole Diam. (in.)	Csg. Lgth. (ft.)	Use	Qual.	Sur. Elev. (ft.)	Aquifer	Pump or Bail test	Lithologic Log and Remarks
W1	O	97	B	Nova Scotia Agricultural College	15	300	69	6	32	D,S	MH	105E	Triassic	63 igpm, 48 Hrs. DD. = 16' REC. 69', 2 Mins.	0-20 sandy till; 20-300 ss
W2 (63)*	B (112)	12	D	Maritime Developers Inc.	6	145	40	6	41	P	MH	165E	Triassic	26 igpm, 25 Hrs. DD. = 9.6' REC. 40', 10 Hrs.	0-34 cl; 34-145 ss
W3	Q	23	C	Soley Lynds	6	105	9	4	60	D	MH	57E	Triassic	15 igpm, 1 Hr. DD. = 2'	0-35 gr; 35-55 sd; 55-105 ss
W4	B	22	C	United Construction Ltd.	6	120	10	4	25	I	MH	45E	Triassic	15 igpm, 15 Mins. DD. = 10'	0-14 sandy till; 14-120 ss
W5	N	101	B	Currie Guildert	15	59	17	4	47	D	MH	40E	Triassic	8 igpm, 15 Mins. DD. = 24'	0-44 sandy till; 44-59 ss
W6	E	108	A	Murray Totten	6	53	8	4	27	D	MH	70E	Triassic	15 igpm, 1 Hr. DD. = 11'	0-6 cl; 6-21 sd; 21-23 cl; 23-53 ss
W7	M	26	B	Leo MacCallum	6	76	4	4	31	P	MH	175E	Horton	8 igpm, 1 Hr. DD. = 28'	
W8	M	59	D	Benny Stewart	15	25	6	4	25	D	MH	125E	Riversdale	8 igpm, 15 Mins. DD. = 14'	0-25 gr
W9	M	10	D	Stewart Reid	15	65	38	4	24	D	MH	143E	Triassic	6 igpm, 15 Mins. DD. = 17'	0-23 sandy till; 23-66 ss
W10	N	97	B	Jack Ross	6	108	7	4	33	D	MH	80E	Triassic	10 igpm, 1 Hr. DD. = 13'	0-10 cl; 10-25 sd & gr; 25-27 cl; 27-108 ss
W11	D	108	A	Francis Wright	6	57	12	4	26	D	MH	80E	Triassic	15 igpm, 1 Hr. DD. = 3'	0-8 till; 8-20 ss; 20-57 ss
W12	H	108	A	Russell Davidson	6	126	4	4	42	D	MH	73E	Triassic	15 igpm, 1 Hr. DD. = 8.5'	0-4 till; 4-26 gr; 26-35 sd; 35-126 ss
W13	E	108	A	Meadow Vale Dairy	6	123	8	6	46	I	MH	56E	Triassic	40 igpm	0-28 gr; 28-39 sd & gr; 39-123 ss
W14 (37)	H	85	A	Basil Fielding	36	28		4	24	D	MH	375E	Horton	3 igpm	0-20 clay till; 20-28 ss
W15	E	72	B	Robert Buchanan	6	40	3	4	10	D	MH	470E	Horton	15 igpm, 1 Hr. DD. = 14', 12 Mins.	0-4 clay till, 4-40 sh
W16	H	75	B	Mrs. Martin MacLean	36	100		5	85	D	MH	160E	Horton	6 igpm, 2 Hrs.	0-83 clay till, 83-100 rock
W17	N	24	C	Bert Wile	6	153	13	4	60	D	MH	66E	Triassic	4 igpm, 1 Hr. DD. = 17'	0-3 mud; 3-29 gr; 29-52 sd; 52-153 ss

* (63) indicates index No. of chemical analysis of sample taken from well and listed in Appendix D.

Appendix C. Contd.

W18	N	24	C	Reginald Butcher	6	117	5	4	82	D	MH	57E	Triassic	15 igpm, 1 Hr. DD. = 7'	0-4 cl; 4-46 gr; 46-70 sd; 70-76 cl; 76-117 ss
W19	H	86	D	Wayne Crowe	15	64	17	4	64	D	MH	275E	gr over Pictou Gp	8 igpm, 15 Mins. DD. = 23'	0-64 sd & gr
W20	N	97	B	Fraser's Pharmacy	6	102	16	4	35	D	MH	61E	Triassic	10 igpm, 1 Hr. DD. = 13'	0-28 sd & gr; 28-30 cl; 30-102 ss
W21 (86)	J	107	A	Alden Cox	6	73	5	4	21	D	MH	80E	Triassic	15 igpm, 1 Hr. DD. = 5', 6 Mins.	0-11 sd & gr; 11-73 ss
W22	Q	23	C	John Higgins	6	104	11	4	59	D	MH	57E	Triassic	6 igpm, 1 Hr. DD. = 16', 25 Mins.	0-50 sd & gr; 50-104 ss
W23	O	24	C	Jack Frizzell	6	100	11	4	50	D	MH	68E	Triassic	12 igpm DD. = 7', 5 Mins.	0-28 gr; 28-41 sd; 41-45 cl; 45-100 ss
W24	O	24	C	Bert Wile	6	126	15	4	42	D	MH	67E	Triassic	10 igpm DD. = 25', 15 Mins.	0-34 gr; 34-36 sd; 36-38 cl
W25	C	25	C	Eric Lynds	6	130	28	4	61	D	MH	67E	Triassic	4 igpm, 12 Mins. DD. = 11'	0-53 sd & gr; 53-130 ss
W26	Q	107	A	Keith Richardson	6	85	5	4	43	D	MH	85E	Triassic	12 igpm, 1 Hr. DD. = 3', 3 Mins.	0-28 sd & gr
W27	E	106	A	Mervin Parker	15	56	3	4	30	D	MH	135E	Triassic	7 igpm, 15 Mins. DD. = 7', 15 Mins.	0-25 sd & gr; 25-56 ss
W28	E	107	A	Everal Patton	15	51	0	4	33	D	MH	74E	Triassic	7 igpm, 15 Mins. DD. = 11'	0-33 sd & gr
W29 (99)	E	99	B	B. C. Dyson	6	148	7	4	113	P	H	26E	Triassic	8 igpm, 1 Hr. DD. = 17'	0-7 sd, 7-56 cl; 56-107 sd; 107-148 ss
W30 (57)	A	51	B	Earl Morrisey	10	106	30	4	106	D	H	150E	Horton	9 igpm, 30 Mins. DD. = 10'	0-12 clay till; 12-20 cl & gr; 20-60 cl; 60-62 gr; 62-90 sd; 90-106 sd & gr
W31	P	45	B	Vincent Watson	36	110		4	60	D	Salt	380E	Windsor		0-50 clay till, 50-110 plaster
W32	F	75	B	Gilbert Ward	10	105	24	4	105	D	MH	280E	Horton	6 igpm, 30 Mins. DD. = 33'	0-68 cl & bldrs; 68-104 cl; 104-105 gr & sd
W33	J	48	C	Douglas Walker	10	25	10	4	20	D	MH	75E	Riversdale	2 igpm, 15 Mins. DD. = 16', 5 Mins.	0-20 gr; 20-25 sl
W34	H	23	C	Clarence MacKenzie	6	156	9	4	96	D	MH	48E	Triassic	5 igpm, 2 Hrs. DD. = 17', 24 Mins.	0-3 mud; 3-15 gr; 15-85 sd & gr; 85-89 cl; 89-156 ss
W35	J	23	C	Walter Naugler	36	123	50			D	MH	45E	Triassic		0-80 gr; 80-94 sd; 94-123 ss
W36	E	108	A	Jack Oates.	6	105	5	4	47	D	MH	55E	Triassic	16 igpm, 1 Hr. DD. = 2', 1 Min.	0-4 mud; 4-38 gr; 38-43 sd; 43-105 ss
W37 (103) (129) (127) (130) (131)	G	98	B	Town of Truro	6	65	6	8	22	P	MH	36.0	gr over Triassic	200 igpm, 72 Hrs. Q_s = 200 igpm	0-5 mud; 5-29 gr; 29-30 cl & gr; 30-34 gr; 34-38 cl & gr; 38-40 gr; 40-50 cl & gr; 50-52 cl; 52-65
W38 (102) (62) (132) (123) (126)	E	98	B	Town of Truro	6	61	19	8	32	P	MH	48.4	gr over Triassic	150 igpm, 72 Hrs. Q_s = 50 igpm	0-10 mud & bldrs; 10-38 sd & gr; 38-50 cl & gr; 50-57 sd & gr; 57-61 ss

No.	Cl.	M.T.	Ref. Map	Owner	Driller Lic. No.	Well Depth (ft.)	Water Depth (ft.)	Hole Diam. (In.)	Csg. Lgth. (ft.)	Use	Qual.	Sur. Elev. (ft.)	Aquifer	Pump or Bail test	Lithologic Log and Remarks
W39	M	97	B	Ross Allen	15	60	12	4	30	D	MH	65E	gr over Triassic	7 igpm, 15 Mins. DD. = 21'	1-26 sd
W40	H	2	C	Bernard Colenbrander	10	87	10	4	72	D	MH	40E	Triassic	20 igpm	0-72 sd & gr; 72-87 sd
W41	C	95	B	Steadman Jennings	10	56	12	4	56	D	MH	160E	Horton	9 igpm, 1 Hr. DD. = 40'	0-46 cl; 46-56 sd & gr
W42 (90)	H	98	B	Webb Frizzell	15	88	32	4	60	D	MH	56E	Triassic	7 igpm, 2 Hrs. DD. = 41', 2 Hrs.	0-54 sd & gr; 54-88 ss
W43 (97)	F	99	B	Andy's Tire Shop	12	175	7	4	135	D	MH	30E	Triassic	3 igpm	0-14 gr; 14-130 sd; 130-175 ss
W44 (96)	O	94	B	Latimer Construction Co.	6	200	8	4	115	I	MH	30E	Triassic	15 igpm, 1 Hr. DD. = 1', 1 Hr. REC. to 8' in 10 Sec.	0-70 gr; 70-92 sd; 92-101 gr; 101-103 sd; 103-105 cl; 105-200 ss
W45	Q	23	C	Lloyd Black	6	96	14	4	83	D	MH	58E	Triassic	12 igpm, 1 Hr. DD. = 11' REC. to 15' in 1 Min.	0-4 mud; 4-80 sd & gr; 80-96 ss
W46	C	25	C	Ivan Ferguson	6	120	17	4	52	D	MH	66E	Triassic	15 igpm, 1 Hr. DD. = 20', 30 Mins. REC. to 22' in 10 Mins.	0-41 gr; 41-47 sd; 47-122 ss
W47	Q	23	C	Harry Fancy	6	133	12	4	90	D	MH	57E	Triassic	12 igpm, 1 Hr. DD. = 10', 1 Hr. REC. to 12' in 3 Mins.	0-3 cl; 3-10 sd; 10-65 gr; 67-78 sd; 78-133 ss
W48 (63)	Q	97	B	Russell Dunn	6	89	38	4	32	D	MH	110E	Triassic	10 igpm, 5 Mins. REC. to 38' in 3 Mins.	0-6 cl; 6-12 sd; 12-26 cl
W49	A	1	C	Richard Ettinger	10	96	20	4	75	D	MH	109E	Triassic	6 igpm, 1 Hr. DD. = 52', 15 Mins. REC. to 20', 20 Mins.	0-30 cl & sd; 30-64 ss & sd; 64-67 ss; 67-70 sh; 70-96 ss
W50 (34)	F	12	D	Walter MacNutt	6	92	30	4	40	D	MH	145E	Triassic	10 igpm, 1 Hr. DD. = 12', 12 Mins. REC. to 30', 11 Mins.	0-4 gr; 4-34 cl
W51	H	34	D	Ernest Hingley	15	74	22	4	54	D	MH	340E	Canso	8 igpm, 15 Mins. DD. = 28', 15 Mins. REC. to 22', 1 Min.	0-50 sd & gr; 50-74 ss
W52	N	75	B	Ralph Weatherbee	6	50	12	4	19	D	MH	260E	Horton	8 igpm DD. = 17'	0-15 cl; 15-50 ss
W53 (106)	H	108	A	Producers Milk Products	6	191	0	6	54	I	S	65E	Triassic	30 igpm	0-20 gr; 20-27 sd; 27-29 cl; 29-121 ss
W54 (107)	H	98	B	Town of Truro	18	400	0	10		P	H	35E	Triassic	280 igpm	0-375 red ss; 375-400 grey & red ss

Appendix C. Contd.

W55 (95)	H	99	B	Town of Truro	18	476		8		P	H	44E	Triassic	235 igpm	0-476 red ss
W56 (94)	B	98	B	Town of Truro	18	238	12	8		P	H	50E	Triassic	250 igpm	0-58 gr; 58-132 red ss; 132-238 purple ss
W57	D	97	B	Town of Truro	18	240		8		P	H	55E	Triassic	250 igpm	0-25 gr; 25-215 red ss; 225-240 purple congl
W58 (61)	O	97	B	Nova Scotia Agricultural College	15	298	63	6	28	P	H	105E	Triassic	62 igpm DD. = 85', 48 Hrs. REC. to 65', 2 Mins.	0-20 sd, cl; 20-298 ss
W59	K	99	B	Town of Truro	6	507	15	10	82	P	M		Triassic	310 igpm	0-50 sd, gr; 50-70 sd, cl; 70-507 mostly ss, minor sh
W60	D	99	B	Maritime Processing Co.	6	382	9	10	150	I	M		Triassic	90 igpm	0-150 sd, cl; 150-325 ss, sh; 325-382 sh

Appendix D. Chemical analyses of groundwater in the Truro area.

Index No	Grid Location	Area	Depth of Well (feet)	Aquifer	Date Sampled	Analyses in parts per million (ppm)																					Ions in equivalents per million (epm)						SSP	SAR
						Ca	Mg	Na	Fe		Mn	SO_4	Cl	NO_3	Alkalinities		Hardness	Ignition Loss	Total Dis-solved Solids	Suspended Matter	Specific Conductance (mhos x 10^{-5})	pH		Field Temp °F	Colour	Turbidity	Cations			Anions				
									Field	Lab					Phenol-phthalein as $CaCO_3$	Methyl Orange						Field	Lab				Ca	Mg	Na	SO_4	Cl	NO_3		
56	11E4B72	Hilden	65	Horton X	29/7/66	28.9	8.0	15.9		0.04	0 2	7.0	24.8	3.0	0	96	105.2			T	26 0		7.3	56	<5		1.44	0.66	0.69	0.15	0.69	0.05	0.25	0.67
55	11E4B95	Truro	65	Horton X	29/7/66	41.7	11.7	21.6		0.06	0.01	56.0	33.7	9.0	0	184	147.3			T	46.0		7.8	60	<5		2.08	0.96	0.94	1.17	0.94	0.15	0.24	0.76
59	11E4B75	Truro	100	Horton X	29/7/66	7.6	1.0	182.7		0.08	T	78.0	285.5	T	16	140	23.0			very low	135.0		8.7	57	<5		0.38	0.08	7.95	2.04	7.95		0.95	16.54
83	11E6D32	Manganese Mines	70	Horton X	6/9/66	40.3	1.5	2.3		0.40	T	12.0	3.5	3.0	0	114	107.0			T	26.0		7.2	59	<5		2.01	0.12	0.10	0.25	0.10	0.06	0 04	0.10
23	11E6D41	Manganese Mines	120	Horton X	29/6/66	10.8	2.2	9.1		T	T	3.0	14.2	T	0	44	37.1			T	11 0		6.4		<5		0.54	0.18	0.40	0.06	0.40		0.35	0.66
57	11E4B51	Hilden	14	Horton O	29/7/66	8.0	3.6	12.5		0.04	0.05	12.0	19.5	5.0	0	24	35.1			T	12.0		6.3	56	<5		0.40	0.30	0.54	0.25	0.54	0.08	0.44	0.92
58	11E6B25	Truro		Horton O	29/7/66	19.2	4.6	11.3		0.14	T	3.0	17.7	1.0	0	72	67.1			T	14.0		7.1	64	<5		0.96	0.38	0.49	0.06	0.49	0.02	0.27	0.60
37	11E6A85	Truro		Horton O	30/6/66	22.5	15.1	5.7		0.08	T	3.0	8.9	T	0	98	119.2			T	24.0		7.9		<5		1.12	1.24	0.25	0.06	0.25		0.09	0.23
72	11E4B24	Brookfield	22	Horton O	3/9/66	33.0	5.7	5.7		0.09	T	28.0	8.8	1.0	0	86	105.4			T	27.0		7.3	61	<5		1.65	0.47	0.25	0.58	6.6	1.0	0.10	0.24
84	11E6D42	Manganese Mines		Horton O	6/9/66	5.7	0.4	8.0		0.06	T	18.0	12.4	T	0	32	15.8				9.0		6.1	55	<5		0.28	0.03	0.35	0.38	0.35		0.52	0.87
25	11E6D14	Truro		Horton O	29/6/66	44.1	17.2	5.7		0.09	T	19.0	8.9	T	0	152	180.4			T	36.0		7.7		<5		2 20	1.41	0.25	0.40	0.25		0 06	0.18
69	11E4B40	Princeport	100	Windsor X		40.0	7.6	9.1		0.16	T	6.0	14.1	14.0	0	148	131.0			T	34.0		8.1	57	<5		2 00	0.63	0.40	0.12	0.40	0.28	0.13	0.35
71	11E4B44	Hilden	100	Windsor X	3/9/66	303.0	7.4	4.6		0.06	0.02	800.0	7.09	T	0	60	787.6				152.0		7.4	54	<5		15.12	0.61	0.20	16.66	0.20		0.01	0.07
27	11E6D35	Brookside	125	Windsor X	29/6/66	58.9	6.1	11.3		2.3	0.06	85.0	17.7	T	0	122	173.3			mod.	46.0		7.7		<5		2.94	0.50	0.49	1.77	0.49		0.13	0.37
65	11E4B5	U. Pleasant Val.		Windsor O	2/9/66	16.6	4.8	3.4		2.30	T	4.0	5.3	T	0	68	61.0			T	16.0		6.5		<5		0.83	0.39	0.15	.08	0.15		0.11	0.19
66	11E4B16	Green Oaks	15	Windsor O	6/9/66	30.2	4.1	3.4		5.0	0.01	13.0	5.3	T	0	92	92.0			T	23.0		7.2	57	<5		1.51	0.34	0.15	0.28	0.15		0.07	0.15
67	11E4B10	Green Oaks		Windsor O	2/9/66	31.0	1.1	3.4		0.03	T	4.0	5.3	1	0	100	82.0			T	24.0		7.9		<5		1.55	0.09	0.15	0.08	0.15	0.02	0.08	0.16
121	11E4B2	Brookfield	30	Windsor O	15/1/68	17.3	2.0	2.4		0.05	T	18.0	8.0	T	0	26	51 4				15 0		6.6		<5	10	0.86	0.16	0.10	0.37	0.23		0.09	0.15
68	11E4B35	Princeport		Windsor O	2/9/66	55.8	3.3	13.7		0.18	T	19.0	21.2	T	0	12	153.2			T	47.0		7.2		<5		2 78	0.27	0.60	0.39	0.60		0.16	0.48
64	11E4B2	Brookfield	17	Windsor O	2/9/66	39.0	6.0	13.7		0.71	1.5	22.0	21.2	T	0	116	122.6			T	55.0		7.5		<5		1.95	0.49	0.60	0.46	0.60		0.20	0.54
120	11E4B2	Brookfield	14	Windsor O	7/12/67	23.5	1.2	6.0		0.22	0.01	51.0	12.4	1.0	0	22	63 6				21.0		6.3		<5	0	1.17	0.10	0.26	1.06	0.35	0.02	0.17	0.33
119	11E4B2	Brookfield	22	Windsor O	7/12/67	25.4	1.0	7.0		0.28	0.01	59.0	21.3	1.0	0	27	68.4				24.0		6.2		<5	0	1.27	0.08	0.30	1.23	0.60	0.02	0.18	0.37
105	11E6B2	Brookfield	30	Windsor O	13/1/68	17.5	2.2	2.1		0.04	T	21.0	6.2	T	0	27	52.8				15 0		6.4		<5	7	0.87	0.18	0.09	0.44	0.18		0.09	0.14
28	11E6D40	Truro	160	Canso X	29/6/66	53.3	15.6	28.9		0.07	0.01	48.0	45.2	9.0	0	136	200.4			T	54 0		7.4		<5		2.66	1.28	1.26	1.00	1.26	0 15	0.24	0.90
13	11E6D30	Manganese Mines		Canso X	28/6/66	23 2	7.6	7.9		4.5	0.02	12.0	12.4	4.0	0	50	90.2			mod.	23.0		7.5		<5		1.16	0.63	0.34	0.25	0.34	0.06	0.16	0.36
11	11E6A77	Greenfield	130	Canso X	28/6/66	12.3	4.9	7.9		5.5	0.08	18.0	12.4	10.0	0	32	34.1			T	18.0		6.6		<5		0.62	0.40	0.34	0.27	0.34	0.16	0.20	0.42
10	11E6A101	Greenfield		Canso X	28/6/66	24.8	8.5	7.9		0.13	0.02	8.0	12.4	2.0	0	88	98.2			T	24.0		7.8		<5		1.24	0.70	0.34	0.16	0.34	0.03	0.15	0.35
8	11E6A40	Camden	83	Canso X	24/6/66	6.4	2.2	9.1		0.22	0.02	22.0	14.0	1.0	0	22	26.1			T	<10		6.6		<5		0.30	0.18	0.40	0.46	0.40	0.12	0.44	0.79
7	11E6A58	Truro		Canso X	24/6/66	30.5	10.3	30.7		0.24	0.04	27.0	47.9	25.0	0	24	119.2			T	42.0		5.9		<5		1.52	0.85	1.34	0.56	1.34	0.40	0.36	1.23
6	11E6A63	Truro	63	Canso X	24/6/66	24.0	2.2	10.2		0.02	T	12.0	16.0	8.0	0	68	91.2			T	21.0		7.2		<5		1.20	0.18	0.44	0.25	0.44	0.13	0.24	0.33
4	11E6A81	Truro	67	Canso X	24/6/66	30.9	4.2	10.2		0.02	T	19.0	16.0	2.0	0	84	97.2			T	21.0		7.8		<5		1.54	0.35	0.44	0.40	0.44	0.03	0.19	0.46

X - Wells into bedrock. O - Wells into surficial material over bedrock.

Appendix D. Contd.

Index No	Grid Location	Area	Depth of Well (feet)	Aquifer	Date Sampled	Analyses in parts per million (ppm)															Specific Conductance (mhos x 10^{-5})	pH		Field Temp °F	Colour	Turbidity	Ions in equivalents per million (epm)						SSP	SAR
						Ca	Mg	Na	Fe		Mn	SO_4	Cl	NO_3	Alkalinities		Hardness	Ignition Loss	Total Dissolved Solids	Suspended Matter							Cations			Anions				
									Field	Lab					Phenolphthalein as $CaCO_3$	Methyl Orange						Field	Lab				Ca	Mg	Na	SO_4	Cl	NO_3		
100	11E6897	Bible Hill	711	Triassic X	10/6/65	33.7	1.9	7.9		0.03	0.02	70.0	12.4	60 0	0	16	92.3			T	50		10.2		10		1 68	0.16	0.34	1.46	0 35	0 97	0.16	0.36
106	11E6A108	Truro	191	Triassic X	2/4/70	17.4	6.8	6 8		<0.02	0 02	2.0	1 0	T	0	79	71.6				20		7 4		5	0	0 87	0 56	0.30	0 04	0.03		0.17	0.35
107	11E6898	Truro	400	Triassic X	2/4/70	24.0	11.1	43.0		<0.01	0.02	40.0	29.0	T	0	107	105.6				47		7.2		>5	0	1 20	0.91	1.87	0.83	0.82		0 47	1.02
108	11E6899	Truro	152	Triassic X	11/8/49	54.3	17.1	50.0		0.0	0.0	62.3	32.9		7.1	121	71.4		297.1	low	200		8.3		5	<25	2.71	1.41	2.18	1.30	0.93		0.35	1.52
109	11E6898	Truro	400	Triassic X	8/9/48	47.1	42.9	15.8		0.0	0.0	15 3	24.3		2 9	93	90 0		180.0	very low	125		8.3		5		2.35	3.53	0.69	0.32	0.69		0.10	0 40
110	11E6898	Bible Hill		Triassic X	21/5/64	119.0	8.0	18.0		0.12	0 20	36 0	40.0	15.0	0	204	383 0	136	433.0	38	64		7.7				5 94	0.66	0.78	0.75	1.13	0 24	0 11	0.43
111	11E6898	Truro	238	Triassic X	1/12/48	111.4	20.0	7.4		0.0	0.0	74.0	11.4	0.0	0	90	131.4		255.7	T	0		7.5		8		5 56	1.65	0.32	1.54	0.32		0.04	0.17
112	11E6A108	Truro	145	Triassic X	2/4/70	24.0	1.9	4.8		0.1	0.02	5.0	<1	T	0	54	68.0				21		6.8		<5	0	1 20	0.16	0.21	0.10	0.03		0.13	0.25
113	11E6898	Truro		Triassic X	1/6/64	26.0	8.0	27.7		0 06	0.03	21.0	35.0	8.0	2	71	38.0	7.0	176	5	33		8.0				1.30	0.66	1.20	0.44	0.99	0.13	0.38	1.22
114	11E6C39	Debert	128	Triassic X	/68	36.5	4.0	12.0		T		9.0	18.0	T	0	25	107 7			0	28		7.8		0	0	1.77	0.33	0.52	0.19	0.51		0.20	0.51
115	11E6C39	Debert	153	Triassic X	/68	36 5	4.0	12.0		4.7		6.0	18.0		0	25	107 7			0	29		7 7		0	0	1.82	0.33	0.52	0.19	0.51		0.20	0.50
50	11E6893	Truro Heights	65	Triassic X	29/7/66	35 7	1.0	7 9		0.04	T	8.0	12.4	3 0	0	90	93.2			T	20		7 7		<5		1.78	0 08	0.34	0.17	0.34	0.05	0.16	0 36
61	11E6897	Truro		Triassic X	/66	36.0	2.0			0 13		24 0	34.0	10.0	0	100	98.2				31		7.9				1 80	0 16	0 09	0.5	0.96	0.16	0.04	0 09
41	11E6C60	Debert	18	Triassic O	14/7/66	10 4	4.4	12.5		0.14	0.02	7.0	19.5	15.0	0	20	44.1		12 0	T	18		7.0		<5		0 52	0 36	0.54	0.15	0.54	0.24	0.38	0.82
49	11E6C32	Onslow	25	Triassic O	15/7/66	44 1	3.4	18 2		0.08	T	13.0	28.4	30.0	0	98	124 3			T	44		8 3	53	<5		2.20	0 28	0.79	0.27	0.79	0.48	0.24	0.71
79	11E6C65	Debert		Triassic O	3/9/66	19.4	2.9	2.3		0.17	T	2.0	3.5	3 0	0	112	60.4			T	18		7 4	63	<5		0.97	0.24	0.10	0.04	0.10	0.06	0.08	0.13
101	11E6A107	Murray	30	Triassic O	29/2/68	12.6	5.6	2.1		0.01	T	4.0	8.9	T	0	42	54.8				18		6.7		<5	<5	0 63	0.46	0.09	0.08	0.25		0.09	0.12
62	11E6898	Truro	57	Triassic O	4/12/68	64 8	13.3	28.0		0.03	0.1	47.0	81.6	12.0	0	106	221.8				66		6.6		<5	3	3.23	1.09	1.27	0.98	2.30	0.19	0.22	0.83
102	11E6898	Truro	57	Triassic O	6/12/68	64 6	13.9	25 8		0.02	1.0	47.0	81.6	12.0	0	102	223.9				66		6.9		<5	2	3 22	1.14	1.12	0.98	2.30	0.20	0.20	0.76
103	11E6898	Truro	30	Triassic O	19/12/68	43 3	13.8	18 7		0.02	T	42.0	52.3	>12.0	0	70	164.8				46		6 9		<5	0	2.12	1.14	0.81	0.87	1.48		0.20	0.63
104	11E6C7	Upper Onslow	50	Triassic O	22/10/68	37.5	8.9	7.1		0.01	T	27.0	5.3	T	4	86	126.0				32		7 6		<5	0	1.87	0.73	0.31	0.56	0.15		0.11	0.27
124	11E6A107	Murray	30	Triassic O	26/2/68	13 6	4.5	1.8		0.01	T	7.0	7.1	T	0	41	53.2				17		6 7		<5	<5	0.68	0 37	0.08	0 15	0.20		0.07	0.11
125	11E6A107	Murray	30	Triassic O	27/2/68	15 2	3.7	1.8		0.01	T	5 0	7.1	T	0	42	54.0				18		6 7		<5	<5	0.76	0.30	0.08	0.10	0.20		0.07	0.11
126	11E6898	Truro	40	Triassic O	3/12/68	65.9	8.5	29.2		0.07	1.0	42.0	83.3	12.0	0	116	199.2				55		6 9		<5	0	3.29	0 70	1 27	0.87	2 35	0.19	0.24	0 90
127	11E6898	Truro	30	Triassic O	6/12/68	43.9	11.6	21 2		0.09	T	47.0	55.0	12.0	0	72	161.1				53		7.3		<5	0	2.19	0.95	0.92	0.98	1.55	0.20	0.23	0 74
129	11E68	Truro		Triassic O	16/12/68	48 0	9.8	22 1		0.03	T	47 0	80.7	8.0	0	74	159.6				50		6 6		<5	0	2.40	0.81	0.91	0 98	2 28	0 13	0.23	0.76
130	11E6898	Truro		Triassic O	18/12/68	44 9	11.9	19 2		0.08	T	46 0	55.8	>12.0	0	74	160.8				48		6.8		<5	4	2.20	0 98	0.84	0.96	1.57		0.21	0.66
131	11E6898	Truro		Triassic O	13/12/68	47 9	7.4	21 3		0.04	T	47.0	62.1	12.0	0	141	150.0				55		6.5		<5	0	2.39	0.61	0.93	0.98	1.75	1.20	0.24	0.76
123	11E6898	Truro	40	Triassic O	22/11/68	60.3	11.0	30.1		0 19	2.5	44.0	75.4	12.0	0	104	195.6				60		7.4		<5	4	3 01	0.91	1.31	0 92	2.13	0.19	0.25	0.96
132	11E6898	Truro	40	Triassic O	4/12/68	64 8	13.3	28.0		0 03	0.1	47.0	81.6	12.0	0	106	221.8				66		6.6		<5	3	3.23	1.09	1.22	0.98	2.30	0.20	0.22	0.83
136	11E6C20	Upper Onslow	50	Triassic O	9/10/68	37.7	5.4	7.2		0.02	T	27.0	T	T	7	118	117.2				30	7.8	8.0	46	<5	0	1.88	0.44	0.31	0.56				
134	11E6C20	Upper Onslow	50	Triassic O	17/10/68	38.2	5.7	6.4		0.03	T	25.0	3 9	T	0	100	118.8				32		7.3	46.5	<5	0	1.91	0.47	0.28	0.52	0.11			
135	11E6C20	Upper Onslow	50	Triassic O	18/10/68	36.9	9.3	7.4		0.01	T	26.0	5.3	T	0	86	130.4				32		7 6	46	<5	0	1.84	0.77	0.32	0.54	0.15			

Index No	Grid Location	Area	Depth of Well (feet)	Aquifer	Date Sampled	Analyses in parts per million (ppm)															Specific Conductance (mhos x 10⁻⁵)	pH		Field Temp °F	Colour	Turbidity	Ions in equivalents per million (epm)						SSP	SAR
									Fe						Alkalinities												Cations			Anions				
						Ca	Mg	Na	Field	Lab	Mn	SO_4	Cl	NO_3	Phenolpthalein as $CaCO_3$	Methyl Orange	Hardness	Ignition Loss	Total Dissolved Solids	Suspended Matter		Field	Lab				Ca	Mg	Na	SO_4	Cl	NO_3		
26	11E6D14	Brookside	39	Triassic X	29/6/66	14.4	4.1	35.2		0.10	0.03	4.0	55.0	10.0	0	8	54.1			T	21		5.4		<5		0.72	0.34	1.53	0.08	1.53	0.16	0.59	2.11
34	11E6D12	Brookside		Triassic X	30/6/66	23.2	0.7	4.8		0.08	T	10.0	7.1	T	0	48	62.1			T	16		8.0		<5		1.16	0.06	0.20	0.21	0.20		0.15	0.27
35	11E6D10	Bible Hill	33	Triassic X	30/6/66	20.0	3.2	7.9		0.07	T	2	12.4	T	0	82	64.1			T	17		7.1		<5		1.00	0.26	0.34	0.04	0.34		0.21	0.43
36	11E6A107	Murray	77	Triassic X	30/6/66	23.2	1.2	5.7		0.01	0.01	12.0	8.9	T	0	40	64.1			T	16		6.0		<5		1.16	0.10	0.25	0.25	0.25		0.16	0.31
38	11E6C4	Onslow		Triassic X	14/7/66	74.9	3.9	12.5		0.05	T	8.0	19.5	15.0	6	184	201.4			T	48		8.6	52	<5		3.74	0.32	0.54	0.17	0.54	0.24	0.12	0.38
39	11E6C4	Onslow	55	Triassic X	14/7/66	35.5	0.2	9.1		0.26	T	2.0	14.2	8.0	0	86	89.2			T	22		8.0	53	<5		1.76	0.02	0.40	0.04	0.40	0.13	0.18	0.42
40	11E6C12	Masstown	75	Triassic X	14/7/66	46.1	0.5	7.9		0.04	T	15.0	12.4	6.0	0	106	117.2			T	30		8.2	53	<5		2.30	0.04	0.34	0.31	0.34	0.10	0.13	0.32
42	11E6C36	Debert		Triassic X	14/7/66	22.4	0.2	5.7		0.05	T	2.0	8.9	T	0	66	57.1			T	14		8.0	58	<5		1.12	0.02	0.25	0.04	0.25		0.18	0.33
44	11E6C63	Debert	42	Triassic X	14/7/66	88.2	9.7	77.8		0.15	0.1	7.0	121.5	50.0	0	116	260.5			T	77		8.3	61	<5		4.40	0.80	3.38	0.15	3.38	0.81	0.39	2.10
45	11E6C55	Belmont	71	Triassic X	14/7/66	55.6	3.2	12.5		0.03	T	5.0	19.5	6.0	6	124	130.3			T	33		8.4		<5		2.77	0.26	0.54	0.10	0.54	0.10	0.15	0.44
46	11E6C45	Onslow	75	Triassic X	14/7/66	16.4	2.9	13.6		0.18	0.04	8.0	21.3	14.0	0	14	55.1			T	22		7.0		<5		0.83	0.24	0.59	0.17	0.59	0.23	0.36	0.81
47	11E6C47	Onslow	50	Triassic X	14/7/66	18.0	1.2	11.3		0.04	T	7.0	17.7	10.0	0	42	49.1			T	16		7.7	50	<5		0.90	0.10	0.49	0.15	0.49	0.16	0.33	0.70
48	11E6C23	Onslow	82	Triassic X	14/7/66	24.4	1.5	10.2		0.03	T	6.0	16.0	6.0	0	64	66.1			T	20		7.7	57	<5		1.22	0.12	0.44	0.12	0.44	0.10	0.25	0.54
51	11E6B91	Lower Truro	240	Triassic X	29/7/66	42.9	1.7	10.3		0.01	T	12.0	16.0	10.0	0	88	114.2			T	24		7.6		<5		2.14	0.14	0.44	0.25	0.44	0.16	0.16	0.42
52	11E6B90	Old Barns	50	Triassic X	29/7/66	63.3	4.8	13.6		0.02	T	40.0	21.3	10.0	0	102	178.4			T	35		7.8		<5		3.16	0.39	0.59	1.25	0.59	0.16	0.14	0.44
53	11E6B80	Clifton	31	Triassic X	29/7/66	57.3	7.8	19.3		0.03	T	18.0	30.1	3.0	0	152	176.4			T	35		7.9	54	<5		2.86	0.64	0.84	0.37	0.84	0.05	0.19	0.63
54	11E6B62	Black Rock	80	Triassic X	29/7/66	44.1	1.7	12.5		0.02	T	8.0	19.5	T	0	124	117.2			T	24		7.8	52	<5		2.20	0.14	0.54	0.17	0.54		0.19	0.50
63	11E6A108	Bible Hill	145	Triassic X	11/8/66	20.4	0.2	11.3		0.05	T	38.0	17.7	2.0	0	48	52.1			T	14		8.2		<5		1.00	0.08	0.50	0.73	0.50	0.03	0.32	0.48
70	11E6B100	Truro	90	Triassic X	3/9/66	91.9	1.8	29.7		0.41	T	17.0	46.1	10.0	0	204	237.2				60		7.5	64	<5		4.58	0.15	1.30	0.35	1.30	0.02	0.21	0.84
73	11E6C9	Onslow	100	Triassic X	3/9/66	32.4	2.5	2.3		0.66	T	3.0	3.5	T	0	112	91.4			T	24		7.4	55	<5		1.62	0.21	0.10	0.06	0.10		0.05	0.10
74	11E6C27	Onslow	230	Triassic X	3/9/66	44.7	0.4	16.0		0.17	T	18.0	24.8	12.0	0	174	113.4			T	46		7.6	57	<5		2.23	0.03	0.70	0.37	0.70	0.24	0.24	0.65
75	11E6C53	Belmont	121	Triassic X	3/9/66	34.3	2.8	17.2		0.12	T	10.0	26.6	18.0	0	88	97.2			T	32		5.9	59	<5		1.71	0.23	0.75	0.21	0.75	0.36	0.28	0.76
80	11E6A108	Truro	87	Triassic X	5/9/66	41.9	0.3	4.6		0.06	T	7.0	7.0	T	0	124	106.2			T	26		7.4	55	<5		2.09	0.03	0.20	0.15	0.20		0.09	0.19
81	11E6D13	Brookside		Triassic X	6/9/66	35.7	1.6	13.7		0.11	T	11.0	21.2	2.0	0	28	95.8			T	27		6.7	57	<5		1.78	0.13	0.60	0.23	0.60	0.04	0.24	0.61
82	11E6D15	Brookside		Triassic X	6/9/66	48.3	0.6	8.0		0.06	T	18.0	12.4	10.0	0	176	123.4			T	32		7.8	59	<5		2.41	0.01	0.35	0.38	0.35	0.20	0.12	0.31
128	11E6B98	Truro	240	Triassic X	2/9/69	46.81	14.4	128.8		0.05	T	93.0	121.5	10.0	8	144	174.0				93		7.8		25	0	2.34	1.18	5.60	1.94	3.43	0.16	0.61	4.27
95	11E6B99	Truro	476	Triassic X	2/9/69	27.58	9.34	73.10		0.04	T	77.0	77.13	T	8	126	107.2				70		7.8		25	0	1.38	0.77	3.18	1.60	2.18		0.60	3.07
98	11E6B100	Truro		Triassic X	2/9/69	48.9	11.58	217.5		0.03	T	75.0	411.3	T	8	128	169.6				180		8.0		25	0	2.44	0.95	9.46	1.56	11.6		0.74	7.26
99	11E6B99	Truro	148	Triassic X	2/9/69	17.64	6.81	220.0		0.08	T	125.0	301.4	T	10	138	72.0				155		8.1		35	15	0.88	0.56	9.57	2.60	8.50		0.87	11.28
96	11E6B94	Truro	200	Triassic X	2/9/69	25.97	5.25	6.7		0.72	T	3.0	7.09	T	4	92	84.4				23		7.6		25	0	1.30	0.43	0.29	0.06	0.20		0.14	0.31
97	11E6B99	Truro	175	Triassic X	2/9/69	43.45	4.67	249.1		0.03	T	125.0	411.3	T	6	120	127.6				190		7.8		25	0	2.17	0.38	10.84	2.60	11.60		0.98	95.89

Appendix D. Contd.

Index No	Grid Location	Area	Depth of Well (feet)	Aquifer	Date Sampled	Analyses in parts per million (ppm)			Fe						Alkalinity							pH					Ions in equivalents per million (epm) Cations			Anions				
						Ca	Mg	Na	Field	Lab	Mn	SO₄	Cl	NO₃	Phenol-phthalein as CaCO₃	Methyl-Orange	Hardness	Ignition Loss	Total Dissolved Solids	Suspended Matter	Specific Conductance (mhos x 10^{-6})	Field	Lab	Field Temp °F	Colour	Turbidity	Ca	Mg	Na	SO₄	Cl	NO₃	SSP	SAR
1	11E6A81	Fraser Brook	60	Canso X	9/8/66	18.8	7.3	11.3		2.0	0.04	12.0	17.7	T	6	150	77.2			high	21.0		8.8		<5		0.94	0.60	0.49	0.25	0.49		0.24	0.56
118	11E6A81	Fraser Brook	60	Canso X	9/8/66	19.6	7.1	20.4		0.28	0.03	4.0	31.9	T	4	132	78.2			low med.	21.0		8.3		<5		0.98	0.58	0.89	0.08	0.89		0.36	1.00
85	11E6D40	East Mountain	140	Canso X	6/9/66	130.8	1.4	2.3		0.37	0.04	400.0	3.5	T	0	48	332.6			T	70		7.6	57	<5		6.53	0.12	0.10	8.33	0.10		0.01	0.05
12	11E6D19	Greenfield		Canso O	28/6/66	5.2	1.9	7.9		0.07	T	2.0	12.4	T	0	22	22.0			T	<10		6.4		<5		0.26	0.16	0.34	0.04	0.34		0.45	0.75
9	11E6A104	Greenfield		Canso O	28/6/66	20.8	4.4	12.5		0.12	0.01	12.0	19.5	15.0	0	46	71.1			T	30		6.3		<5		1.04	0.36	0.54	0.25	0.54	0.24	0.28	0.65
5	11E6A82	Archibald		Canso O	24/6/66	7.2	2.8	22.1		0.20	T	4.0	34.6	T	0	4	30.1			T	12		5.1		<5		0.36	0.23	0.96	0.08	0.96		0.62	1.77
3	11E6A88	Archibald		Canso O	24/6/66	21.2	0.4	8.5		0.05	0.03	21.0	13.3	T	0	36	56.1			T	14		7.2		<5		1.06	0.03	0.37	0.44	0.37		0.25	0.50
2	11E6A80	Archibald		Canso O	24/6/66	6.0	3.0	8.5		0.05	T	11.0	13.3	T	2	102	28.1			low	23		8.3		<5		0.30	0.25	0.37	0.23	0.37		0.40	0.71
122	11E6A81	Archibald		Canso O	10/6/66	6.4	3.4	5.2		0.65	1.00	3.0	8.0	T	0	32	34.0			low	<10		6.9		50		0.32	0.28	0.23	0.06	0.23		0.27	0.41
117	11E6D26	Riversdale		Canso O	24/9/66	0.96	1.56	1.45		0.01	T	3.0	3.6	T	0	16	8.8				<1		5.9		5	0	0.05	0.13	0.06	0.06	0.10		0.26	0.21
29	11E6D59	North River		Riversdale X	29/6/66	50.9	8.8	6.8		1.4	0.02	160.0	10.6	T	0	152	164.3			high	55		7.4		<5		2.54	0.72	0.30	3.33	0.30		0.08	0.23
60	11E6D46	Riversdale	205	Riversdale X	5/8/66	45.7	4.1	12.5		0.06	T	66.0	19.5	T	0	100	131.3			T	15		7.9	54	<5		2.28	0.34	0.54	1.37	0.55		0.17	0.48
30	11E6D42	North River	95	Riversdale X	29/6/66	45.6	3.1	34.0		2.3	0.3	60.0	53.2	3.0	0	148	170.3			low	46		7.2		<5		2.28	0.25	1.45	1.25	1.45	0.03	0.37	1.31
33	11E6D61	North River	95	Riversdale X	29/6/66	12.4	T	61.3		0.05	0.01	130.0	17.7	1.0	0	74	31.1			T	38		6.7		<5		0.62		2.69	2.71	0.49	0.01	0.81	4.79
77	11E6C71	Onslow	50	Riversdale X	3/9/66	38.2	8.6	12.6		0.34	0.02	13.0	19.5	T	0	142	130.6			T	32		7.9	55	<5		1.91	0.71	0.55	0.27	0.55		0.17	0.48
76	11E6C51	Onslow	100	Riversdale X	3/9/66	196.6	4.8	2.3		2.5	T	540.0	3.5	T	0	172	511.4				118		7.4	52	<5		9.81	0.39	0.10	11.24	0.10		0.01	0.04
14	11E6D44	Riversdale	16	Riversdale O	28/6/66	44.5	6.3	7.9		0.02	0.01	10.0	12.4	40.0	0	24	138.3			T	42		6.7		<5		2.22	0.52	0.34	0.21	0.34	0.65	0.11	0.29
15	11E6D52	Riversdale		Riversdale O	28/6/66	5.6	1.0	4.5		0.01	T	2.0	7.1	T	0	16	19.0			T	<10		6.6		<5		0.28	0.08	0.20	0.04	0.20		0.35	0.46
16	11E6D54	Riversdale		Riversdale O	28/6/66	24.4	2.4	18.2		T	T	30.0	28.4	3.0	0	52	72.1			T	22		6.7		<5		1.22	0.20	0.79	0.06	0.79	0.05	0.36	0.94
17	11E6D45	Riversdale	9.5	Riversdale O	29/6/66	6.4	0.7	6.8		0.02	T	3.0	10.6	T	0	16	20.0			high	<10		6.3		<5		0.32	0.06	0.30	0.06	0.30		0.44	0.68
22	11E6D40	East Mountain	12.1	Riversdale O	29/6/66	53.3	2.4	11.9		0.02	T	5.0	18.4	5	0	128	144.3			T	34		7.0		<5		2.66	0.20	0.52	0.10	0.52	0.08	0.15	0.43
116	11E7C65	West River Station		Cumberland X	18/10/66	119.3	44.4	920.0		19.0	0.10	80.0	1420.0	1.0	0	44	481.4				500		7.3		350	320	2.74	0.36	40.0	1.66	40.0	0.02	0.81	18.26
31	11E6D86	Central North R.		Cumberland X	29/6/66	37.7	8.8	126.0		T	T	36.0	196.8	T	0	112	130.3			T	78		7.7		<5		1.88	0.72	5.48	0.75	5.48		0.68	4.80
21	11E6D101	Kemptown		Cumberland X	29/6/66	12.4	1.7	5.7		T	T	2.0	8.9	T	0	44	38.0			T	11		6.5		<5		0.62	0.14	0.25	0.04	0.25		0.25	0.40
18	11E6D76	Kemptown	8.3	Cumberland O	29/6/66	6.6	2.9	9.1		0.01	T	12.0	14.2	12.0	0	6	27.1			T	14		5.2		<5		0.33	0.24	0.40	0.25	0.40	0.19	0.41	0.74
19	11E6D93	Kemptown		Cumberland O	29/6/66	30.9	2.9	1.7		T	T	17.0	2.7	2.0	0	70	87.2			T	23		7.5		5		1.54	0.24	0.07	0.30	0.07	0.03	0.04	0.08
20	11E6D100	Kemptown	16.2	Cumberland O	29/6/66	4.8	1.2	10.2		0.25	T	5.0	16.0	T	0	20	15.0			very low	<10		6.6		<5		0.24	0.10	0.44	0.10	0.44		0.57	1.08
32	11E6D107	Central North R.	12	Cumberland O	29/6/66	4.4	1.2	9.1		0.02	T	5.0	14.2	3.0	0	22	16.0			T	<10		5.9		<5		0.27	0.10	0.40	0.10	0.40	0.05	0.55	0.99
78	11E6C97	McCallum	22	Cumberland O	3/9/66	8.1	1.4	4.6		0.28	T	2.0	7.0	1.0	0	78	26.2			T	9		6.7	55	<5		0.40	0.11	0.20	0.04	0.20	0.02	0.28	0.39
43	11E6C84	Debert		Cumberland O	14/7/66	4.4	1.2	8.5		0.03	T	3.0	13.3	T	0	20	16.0			very low	<10		7.2	52	5		0.22	0.10	0.37	0.06	0.37		0.34	0.93
24	11E6D34	Brookside	204	Triassic X	29/6/66	32.5	2.9	7.9		0.02	T	4.0	12.4	T	0	130	94.2			T	23		7.8		<5		1.62	0.24	0.34	0.08	0.34		0.16	0.36

Appendix E. Chemical analyses of water from the Salmon River, Colchester County, Nova Scotia

						Analyses in parts per million (ppm)								Alkalinities							pH					Ions in equivalents per million (epm)							
																										Cations			Anions				
Index No	Grid Location	Area	River Stage (ft)	River Flow (c.f.s.)	Date Sampled	Ca	Mg	Na	Fe	Mn	SO₄	Cl	NO₃	Phenolphthalein as CaCO₃	Methyl Orange	Hardness	Ignition Loss	Total Dissolved Solids	Suspended Matter	Specific Conductance (mhos x 10⁻⁵)	Field	Lab	Field Temp °F	Colour	Turbidity	Ca	Mg	Na	SO₄	Cl	NO₃	SSP	SAR
86.1	11E6A107	Murray	2.6	81.2	28/6/67	3.6	1.6	9.8	0.16	0.03	3.0	15.0	T	0	16	16.4			T	9		7.4		25	7	0.18	0.13	0.43	0.06	0.42		0.58	1.08
86.2	11E6A107	Murray	2.49	70.2	12/7/67	5.8	2.14	10.30	0.16	0.02	8.0	15.9	T	0	28	23.3				12		7.9		25	8	0.29	0.18	0.19	0.16	0.20		0.49	0.93
86.3	11E6A107	Murray	2.46	65.4	26/7/67	6.7	1.7	13.2	0.24	T	7.0	20.4	T	0	36	24.4				13		7.0		30	8	0.33	0.14	0.57	0.15	0.57		0.55	1.18
86.4	11E6A107	Murray	2.6	90.5	9/8/67	6.9	1.3	10.1	0.18	T	4.0	15.6	T	0	20	22.4				12		7.2		70	12	0.34	0.11	0.44	0.08	0.44		0.49	0.92
86.5	11E6A107	Murray	2.4	55.7	23/8/67	8.0	2.6	11.4	0.16	T	6.0	17.7	T	0	26	28.4				16		7.2		20	7	0.40	0.22	0.50	0.12	0.50		0.45	0.90
86.6	11E6A107	Murray	3.0	209.0	6/9/67	6.4	1.8	8.7	0.17	T	3.0	8.9	T	0	12	23.5				5		7.3		115	18	0.32	0.15	0.38	0.06	0.25		0.45	0.78
86.7	11E6A107	Murray	2.46	65.4	22/9/67	6.4	1.5	9.9	0.04	T	4.0	13.3	T	0	19	22.3				13		6.8		5	2	0.32	0.12	0.43	0.08	0.38		0.49	0.92
86.8	11E6A107	Murray	2.47	67.0	4/10/67	6.3	1.9	9.0	0.21	T	4.0	14.2	T	0	20	23.5				12		7.2		40	7	0.31	0.16	0.39	0.08	0.40		0.45	0.81
86.9	11E6A107	Murray	3.18	285.0	18/10/67	3.9	1.1	5.3	0.24	0.02	3.0	1.8	T	0	8	14.2				1		7.1		35	14	0.19	0.10	0.23	0.06	0.05		0.45	0.61
86.10	11E6A107	Murray	3.10	348.0	1/11/67	4.4	1.3	19.0	0.27	T	3.0	8.9	T	0	7	16.3				5		7.0		45	26	0.22	0.11	0.83	0.05	0.25		0.72	2.05
86.11	11E6A107	Murray	3.97	758.0	15/1/67	3.3	1.0	5.0	0.23	T	5.0	4.4	T	0	6.5	12.4				1		6.9		40	18	0.16	0.08	0.22	0.10	0.12		0.47	0.62
86.12	11E6A107	Murray	4.03	805.0	29/11/67	2.5	0.8	3.5	0.21	T	4.0	3.5	T	0	5.5	9.6				0		6.6		30	12	0.12	0.07	0.15	0.08	0.10		0.44	0.49
87.1	11E6B17	Union Station			28/6/67	2.2	1.5	8.6	0.26	0.06	3.0	13.3	T	0	12	12.6				7		7.1		35	3	0.11	0.12	0.37	0.06	0.39		0.62	1.10
87.2	11E6B17	Union Station			12/7/67	4.1	1.41	14.2	0.15		7.0	17.7	T	0	24	16.0				12		8.0		30	9	0.20	0.12	0.34	0.15	0.34		0.66	1.54
87.3	11E6B17	Union Station			26/7/67	4.5	1.5	14.3	0.29		5.0	22.2	T	0	28	18.0				13		6.9		30	12	0.23	0.12	0.62	0.10	0.62		0.64	1.49
87.4	11E6B17	Union Station			9/8/67	5.3	1.5	10.8	0.26	T	2.0	16.8	T	0	16	19.2				11		7.1		75	10	0.26	0.12	0.47	0.04	0.47		0.55	1.07
87.5	11E6B17	Union Station			23/8/67	5.8	1.3	13.7	0.22	T	6.0	21.3	T	0	18	19.6				15		7.1		25	7	0.29	0.11	0.60	0.12	0.60		0.40	1.34
87.6	11E6B17	Union Station			6/9/67	16.0	1.7	6.2	0.21	T	2.0	10.6	T	0	18	47.0				7		7.6		115	20	0.84	0.14	0.27	0.04	0.30		0.22	0.39
87.7	11E6B17	Union Station			22/9/67	3.7	1.3	11.1	0.16	T	4.0	16.8	T	0	13	14.6				13		6.9		10	9	0.18	0.11	0.48	0.08	0.47		0.68	1.26
87.8	11E6B17	Union Station			4/10/67	6.3	1.4	9.4	0.27	T	3.0	14.2	T	0	12	21.5				11		7.3		45	8	0.31	0.12	0.42	0.06	0.40		0.49	0.90
87.9	11E6B17	Union Station			18/10/67	2.8	0.9	4.7	0.21	T	3.0	1.8	T	0	8	10.7				1		7.1		45	21	0.14	0.07	0.20	0.06	0.05		0.49	0.63
87.10	11E6B17	Union Station			1/11/67	2.8	1.0	9.1	0.20	T	2.0	3.5	T	0	6	11.1				2		6.8		35	20	0.14	0.08	0.40	0.04	0.09		0.64	1.19
87.11	11E6B17	Union Station			15/11/67	3.5	1.0	3.1	0.34	T	5.0	4.4	T	0	7	12.9				1		6.7		45	18	0.17	0.08	0.13	0.10	0.12		0.34	0.38
87.12	11E6B17	Union Station			29/11/67	2.5	0.6	3.0	0.18	T	3.0	3.5	T	0	4	8.7				0		6.6		25	9	0.12	0.05	0.13	0.06	0.10		0.43	0.44
88.1	11E6D46	Riverdale			28/6/67	1.8	1.6	4.6	0.32	0.06	2.0	7.1	T	0	8	12.2				0		6.7		80	12	0.90	0.13	0.20	0.04	0.20		0.47	0.60
88.2	11E6D46	Riverdale			12/7/67	2.8	1.36	6.8	0.33	0.02	7.0	10.6	T	0	16	12.8				9		7.4		40	15	0.14	0.11	0.16	0.15	0.16		0.54	0.83
88.3	11E6D46	Riverdale			26/7/67	2.7	1.3	9.2	0.58	T	8.0	14.2	T	0	16	12.8				8		6.9		80	25	0.14	0.11	0.40	0.17	0.40		0.62	1.15
88.4	11E6D46	Riverdale			9/8/67	3.7	0.0	6.8	0.44	T	4.0	10.6	T	0	8	9.2				2		6.7		120	22	0.18		0.30	0.08	0.29		0.62	0.97
88.5	11E6D46	Riverdale			23/8/67	4.2	1.1	5.1	0.51	T	5.0	8.0	T	0	15	14.8				7		6.8		90	19	0.21	0.09	0.22	0.10	0.22		0.43	0.57
88.6	11E6D46	Riverdale			6/9/67	3.5	1.5	5.2	0.21	T	3.0	8.9	T	0	6	13.5				0		6.5		140	25	0.17	0.12	0.23	0.06	0.25		0.43	0.59
88.7	11E6D46	Riverdale			22/9/67	4.4	1.1	6.0	0.39	T	4.0	8.9	T	0	12	15.5				7		7.0		70	18	0.22	0.09	0.26	0.08	0.25		0.44	0.66

T = concentration 0.01 ppm　　SSP = soluble sodium percentage　　SAR = sodium adsorption ratio

Appendix E. Contd.

Index No	Grid Location	Area	River Stage (ft)	River Flow (cfs)	Date Sampled	Analyses in parts per million (ppm)														Specific Conductance (mhos x 10^{-5})	pH		Field Temp °F	Colour	Turbidity	Ions in equivalents per million (epm)						SSP	SAR
														Alkalinities												Cations			Anions				
						Ca	Mg	Na	Fe	Mn	SO_4	Cl	NO_3	Phenolphthalein as $CaCO_3$	Methyl Orange	Hardness	Ignition Loss	Total Dissolved Solids	Suspended Matter		Field	Lab				Ca	Mg	Na	SO_4	Cl	NO_3		
88.8	11E6D46	Riverdale			4/10/67	3.0	1.2	5.2	0.39	T	2.0	5.3	T	0	8	12.0				2		7.2		85	21	0.15	0.10	0.23	0.04	0.15		0.48	0.64
88.9	11E6D46	Riverdale			18/10/67	1.9	0.8	2.9	0.37	T	2.0	1.8	T	0	7	8.0				0		6.4		80	29	0.09	0.07	0.13	0.04	0.05		0.44	0.45
88.10	11E6D46	Riverdale			1/11/67	2.4	0.9	3.2	0.03	T	2.0	1.8	T	0	4	8.5				0		6.4		90	31	0.12	0.07	0.14	0.04	0.05		0.42	0.45
88.11	11E6D46	Riverdale			15/11/67	2.4	0.9	2.2	0.28	0.01	4.0	3.5	T	0	2.5	9.8				0		6.6		80	21	0.12	0.07	0.10	0.08	0.10		0.33	0.31
88.12	11E6D46	Riverdale			22/11/67	1.5	0.7	2.4	0.24	0.01	2.0	1.8	T	0	2.5	6.6				0		6.1		55	19	0.07	0.06	0.10	0.04	0.05		0.44	0.41
89.1	11E6D76	Kemptown			28/6/67	2.2	1.1	4.0	0.14	0.03	3.0	6.2	T	0	12	11.0				0		7.1		20	70	0.11	0.09	0.17	0.06	0.17		0.46	0.55
89.2	11E6D76	Kemptown			12/7/67	2.3	1.61	5.03	0.09	0.03	11.0	7.8	T	0	20	13.0				5		7.5		25	8	0.11	0.13	0.22	0.23	0.22		0.47	0.62
89.3	11E6D76	Kemptown			26/7/67	13.0	1.0	7.4	0.22	T	4.0	11.5	T	0	26	37.3				9		7.3		25	11	0.65	0.08	0.32	0.08	0.32		0.31	0.53
89.4	11E6D76	Kemptown			9/8/67	6.1	0.2	6.3	0.18	T	4.0	9.7	T	0	18	16.0				6		7.2		45	10	0.30	0.02	0.27	0.08	0.27		0.44	0.48
89.5	11E6D76	Kemptown			23/8/67	5.1	0.6	4.6	0.18	T	4.0	6.2	T	0	18	15.2				8		7.2		25	11	0.25	0.06	0.20	0.08	0.20		0.40	0.51
89.6	11E6D76	Kemptown			6/9/67	3.8	1.3	6.2	0.12	T	2.0	7.1	T	0	12	14.7				1		6.6		70	10	0.22	0.11	0.27	0.04	0.20		0.48	0.70
89.7	11E6D76	Kemptown			22/9/67	3.5	1.0	4.9	0.09	T	2.0	6.2	T	0	13	12.8				2		7.1		10	7	0.17	0.08	0.21	0.04	0.18		0.45	0.59
89.8	11E6D76	Kemptown			4/10/67	3.8	1.1	5.1	0.22	T	2.0	5.3	T	0	10	14.0				2		7.2		35	8	0.19	0.09	0.22	0.04	0.15		0.44	0.59
89.9	11E6D76	Kemptown			18/10/67	3.1	0.8	3.0	0.41	T	2.0	1.8	T	0	8	11.0				1		7.0		150	19	0.15	0.07	0.13	0.04	0.05		0.37	0.39
89.10	11E6D76	Kemptown			1/11/67	2.9	1.0	3.1	0.38	T	2.0	3.5	T	0	7	11.5				1		6.7		25	18	0.14	0.08	0.13	0.04	0.10		0.37	0.40
89.11	11E6D76	Kemptown			15/11/67	2.8	0.8	2.2	0.19	T	3.0	2.7	T	0	5.5	10.2				0		6.6		45	11	0.14	0.07	0.10	0.06	0.07		0.32	0.30
89.12	11E6D76	Kemptown			29/11/67	2.2	0.8	2.8	0.18	T	3.0	3.5	T	0	4.5	8.8				0		6.3		20	2	0.11	0.07	0.12	0.06	0.10		0.41	0.41
90.1	11E6D98	Truro			1/11/67	4.4	1.3	5.0	0.28	T	2.0	8.9	T	0	12	16.3				6		7.0		35	22	0.22	0.11	0.22	0.04	0.25		0.40	0.58
90.2	11E6D98	Truro			15/11/67	3.5	1.0	3.0	0.32	0.06	5.0	4.4	T	0	8	12.9				1		6.7		45	12	0.17	0.08	0.13	0.10	0.12		0.34	0.51
90.3	11E6D98	Truro			29/11/67	4.2	0.6	3.0	0.29	0.01	3.0	4.4	T	0	7	13.0				1		6.5		45	11	0.21	0.05	0.13	0.06	0.12		0.33	0.50
90.4	11E6D98	Truro			13/12/67	3.2	0.5	2.8	0.27	T	6.0	7.1	T	0	8	10.4				0		6.8		50	30	0.16	0.04	0.12	0.12	0.20		0.38	0.55
91	11E6C2	Farnham Brook			13/12/67	9.4	1.2	2.0	0.42	T	8.0	5.3	T	0	12	28.8				10		6.3		65	69	0.47	0.10	0.09	0.17	0.15		0.13	0.16
92	11E6C2	North River			13/12/67	1.8	2.2	2.5	0.23	T	16.0	5.3	T	0	10	13.6				0		6.6		45	30	0.09	0.18	0.11	0.33	0.15		0.29	0.30
93	11E6C3	McCurdy River			13/12/67	5.6	0.6	2.0	0.33	T	6.0	3.5	T	0	14	16.8				0		6.5		70	90	0.28	0.05	0.09	0.12	0.10		0.21	0.21
94	11E6B96	McLure Brook			13/12/67	5.0	0.5	2.2	0.30	T	8.0	5.3	T	0	8	14.8				1		6.4		60	55	0.25	0.04	0.10	0.17	0.15		0.25	0.25
133.1	11E6A27	Fraser Brook			1/8/67	4.1	1.8	2.6	0.03	0.0	4.4	2.8	0.35	0	13.2	17.6		28.1		44.8		6.7		70	1	0.205	0.148	0.113	0.09	0.08	0.01	0.26	0.27
133.2	11E6A27	Fraser Brook			24/9/67	4.1	2.1	2.8	0.64	0.29	4.1	5.2	0.32	0	15.6	18.9		33.8		54.6		6.7		30	0	0.205	0.173	0.122	0.085	0.147	0.005	0.29	0.28
133.3	11E6A27	Fraser Brook			26/9/67	3.2	1.6	2.5	0.37	0.03	3.8	4.7	0.05	0	10.6	14.6		26.9		43.7		7.0		50	0	0.16	0.13	0.11	0.08	0.13	0.001	0.29	0.28
133.4	11E6A27	Fraser Brook			28/9/67	3.8	1.8	2.8	0.27	0.03	3.5	4.0	0.02	0	14.1	16.9		29.0		49.0		7.0		30	0	0.19	0.15	0.12	0.07	0.11	0.0	0.29	0.30
133.5	11E6A27	Fraser Brook			30/9/67	3.8	1.5	2.6	0.37	0.03	3.6	5.1	0.05	0	10.4	15.7		27.6		44.3		6.8		60	0	0.19	0.12	0.11	0.08	0.14	0.001	0.28	0.29
133.6	11E6A27	Fraser Brook			2/10/67	3.5	1.6	2.7	0.30	0.03	3.1	5.3	0.01	0	12.5	15.4		28.4		45.0		7.1		55	0	0.18	0.13	0.12	0.06	0.15	0.0	0.29	0.30

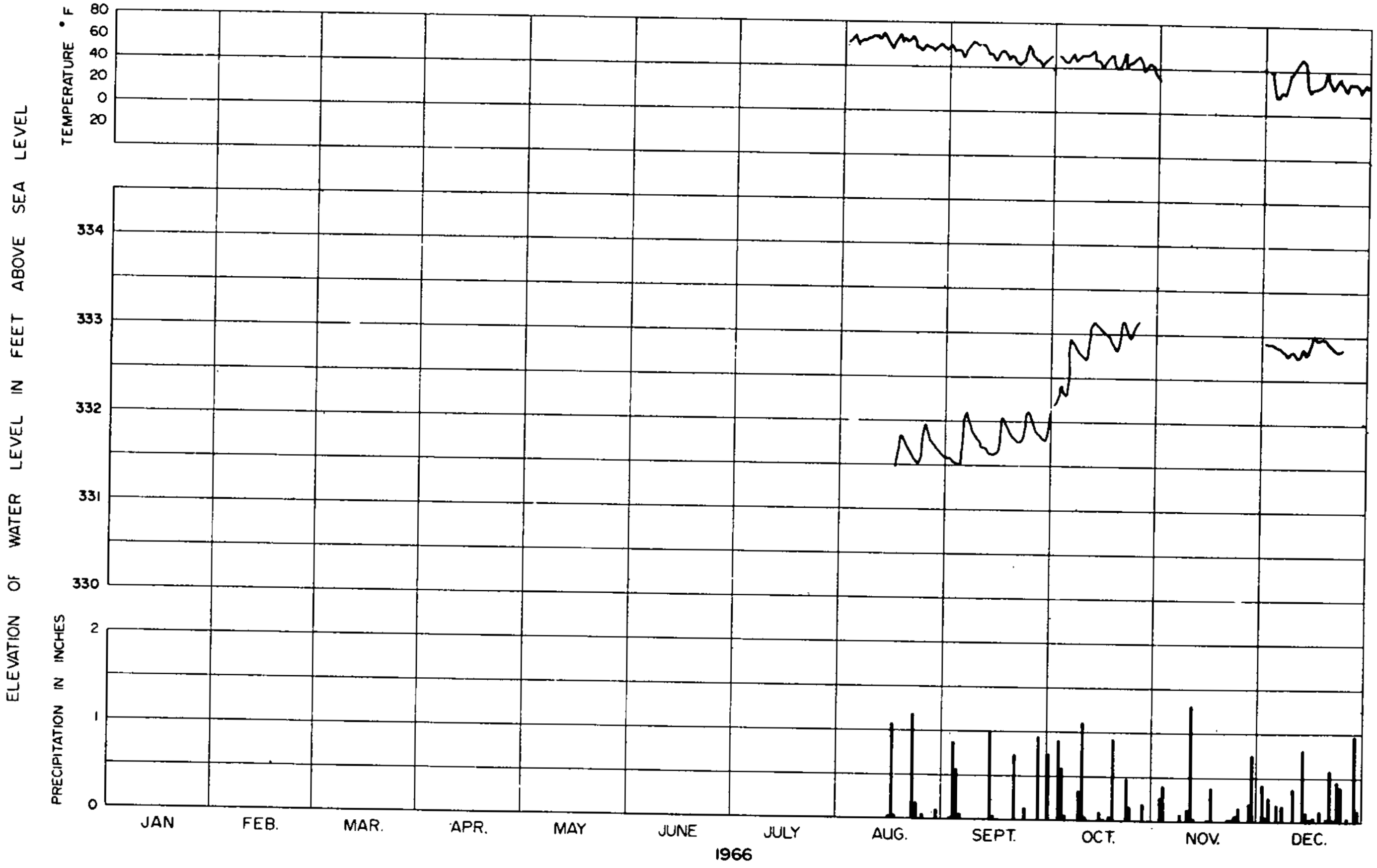
						Analyses in parts per million (ppm)																				Ions in equivalents per million (epm)							
														Alkalinities							pH					Cations			Anions				
Index No	Grid Location	Area	River Stage (ft)	River Flow (cfs)	Date Sampled	Ca	Mg	Na	Fe	Mn	SO_4	Cl	NO_3	Phenol-phthalein as $CaCO_3$	Methyl Orange	Hardness	Ignition Loss	Total Dis-solved Solids	Suspended Matter	Specific Conductance (mhos x 10^{-6})	Field	Lab	Field Temp °F	Colour	Turbidity	Ca	Mg	Na	SO_4	Cl	NO_3	SSP	SAR
133.7	11E6A27	Fraser Brook			4/10/67	4.0	1.8	2.9	0.23	0.02	4.1	4.6	0.05	0	13.6	17.4		30.1		50.0		7.1		40	0	0.20	0.15	0.13	0.08	0.13	0.001	0.28	0.30
133.8	11E6A27	Fraser Brook			6/10/67	4.0	1.8	2.8	0.23	0.08	3.3	4.7	0.04	0	14.1	17.4		29.6		49.2		7.2		40	0	0.20	0.15	0.12	0.07	0.13	0.001	0.28	0.29
133.9	11E6A27	Fraser Brook			8/10/67	4.0	1.9	2.9	0.20	0.02	3.7	4.8	0.05	0	14.7	17.8		30.5		51.7		7.2		30	0	0.20	0.16	0.13	0.08	0.14	0.001	0.27	0.30
133.10	11E6A27	Fraser Brook			10/10/67	2.5	1.2	1.9	0.52	0.08	4.9	4.8	0.77	0	2.9	11.2		21.2		35.5		6.1		100	0	0.13	0.10	0.08	0.10	0.14	0.012	0.33	0.25
133.11	11E6A27	Fraser Brook			12/10/67	2.5	1.1	2.0	0.43	0.02	4.5	4.0	0.07	0	3.5	10.8		20.0		32.1		6.6		70	0	0.13	0.09	0.09	0.09	0.11	0.001	0.32	0.27
133.12	11E6A27	Fraser Brook			14/10/67	2.5	1.2	2.1	0.41	0.01	4.5	3.7	0.08	0	4.9	11.2		20.7		32.8		6.6		50	0	0.13	0.10	0.09	0.09	0.10	0.001	0.31	0.27
133.13	11E6A27	Fraser Brook			16/10/67	2.5	1.3	2.2	0.41	0.05	4.2	3.6	0.13	0	5.8	11.6		21.4		35.3		6.9		50	0	0.13	0.11	0.10	0.09	0.10	0.002	0.32	0.28
133.14	11E6A27	Fraser Brook			18/10/67	2.2	1.1	2.1	0.47	0.04	4.0	4.6	0.87	0	4.5	10.1		21.2		35.1		6.3		70	0	0.11	0.09	0.09	0.08	0.13	0.014	0.36	0.29
133.15	11E6A27	Fraser Brook			20/10/67	2.1	1.0	2.1	0.41	0.01	3.7	4.2	0.07	0	5.1	9.4		20.0		33.2		6.8		60	0	0.10	0.08	0.09	0.08	0.12	0.001	0.35	0.30
133.16	11E6A27	Fraser Brook			22/10/67	2.4	1.3	2.2	0.36	0.04	3.9	4.3	0.07	0	6.2	11.4		21.7		34.3		6.8		40	0	0.12	0.11	0.10	0.08	0.12	0.001	0.32	0.28
133.17	11E6A27	Fraser Brook			24/10/67	2.4	1.3	2.2	0.35	0.03	4.6	3.6	0.07	0	6.9	11.4		22.1		36.4		7.0		40	0	0.12	0.11	0.10	0.09	0.10	0.001	0.31	0.28
133.18	11E6A27	Fraser Brook			26/10/67	2.5	1.4	2.4	0.0	0.0	4.3	3.8	0.07	0	7.3	12.0		23.1		38.3		6.9		40	0	0.13	0.12	0.10	0.09	0.11	0.001	0.33	0.30
133.19	11E6A27	Fraser Brook			26/10/67	2.6	1.3	2.3	0.0	0.0	4.4	3.9	0.05	0	7.7	11.9		22.2		38.6		7.0		40	0	0.13	0.11	0.10	0.09	0.11	0.001	0.32	0.29
133.20	11E6A27	Fraser Brook			28/10/67	2.8	1.4	2.3	0.0	0.0	4.2	4.1	0.09	0	7.2	12.8		23.2		37.4		7.0		40	0	0.14	0.12	0.10	0.09	0.12	0.001	0.30	0.28
133.21	11E6A27	Fraser Brook			28/10/67	2.6	1.4	2.3	0.0	0.0	4.5	4.2	0.02	0	7.6	12.3		22.5		38.4		6.9		40	0	0.13	0.12	0.10	0.09	0.12	0.0	0.31	0.29
133.22	11E6A27	Fraser Brook			30/10/67	2.4	1.3	2.3	0.33	0.03	4.2	4.8	0.02	0	6.9	11.4		22.0		36.9		6.9		50	0	0.12	0.11	0.10	0.09	0.14	0.0	0.33	0.30
133.23	11E6A27	Fraser Brook			1/11/67	2.4	1.4	2.3	0.31	0.04	4.2	4.0	0.01	0	8.4	11.8		20.5		39.0		7.0		40	0	0.12	0.12	0.10	0.09	0.11	0.0	0.32	0.29
133.24	11E6A27	Fraser Brook			3/11/67	2.8	1.5	2.5	0.33	0.02	4.5	4.7	0.23	0	9.1	13.2		25.0		43.0		7.1		40	0	0.14	0.12	0.11	0.09	0.13	0.004	0.31	0.30
133.25	11E6A27	Fraser Brook			6/1/68	3.3	0.3	2.9	0.15	0.02	5.9	2.5	0.0	0	5.3	9.4		21.9		33.1		6.7		20	0.2	0.17	0.03	0.13	0.12	0.07	0.0	0.41	0.41
133.26	11E6A27	Fraser Brook			13/1/68	3.1	0.8	3.2	0.16	0.03	5.4	4.5	0.2	0	6.4	11.0		24.8		38.8		6.7		5	0.4	0.16	0.07	0.14	0.11	0.13	0.003	0.40	0.42
133.27	11E6A27	Fraser Brook			20/1/68	3.0	0.7	2.2	0.02	0.10	3.2	2.9	0.0	0	6.6	10.3		19.3		35.3		6.5		10	0.6	0.15	0.06	0.10	0.07	0.08	0.0	0.33	0.30
133.28	11E6A27	Fraser Brook			27/1/68	2.0	0.7	2.3	0.02	0.10	4.0	2.7	0.0	0	6.4	7.9		18.7		35.5		6.4		15	0.7	0.10	0.06	0.10	0.08	0.08	0.0	0.41	0.36
133.29	11E6A27	Fraser Brook			4/2/68	2.0	0.6	1.9	0.02	0.10	3.2	2.4	0.0	0	4.4	7.5		15.4		31.2		6.6		15	3.0	0.10	0.05	0.08	0.07	0.07	0.0	0.38	0.30
133.30	11E6A27	Fraser Brook			10/2/68	2.0	0.7	2.2	0.01	0.0	4.0	2.8	0.0	0	5.2	7.9		18.3		36.1		6.7		10	0.6	0.10	0.06	0.10	0.08	0.08	0.0	0.40	0.34
133.31	11E6A27	Fraser Brook			17/2/68	2.0	1.5	2.6	0.03	0.0	5.6	2.8	0.20	0	7.4	11.2		22.9		40.0		6.6		5	0.5	0.10	0.12	0.11	0.12	0.08	0.003	0.35	0.34
133.32	11E6A27	Fraser Brook			24/2/68	3.2	1.7	3.0	0.05	0.1	4.1	2.9	0.0	0	8.6	14.8		32.1		43.1		6.7		20	0.7	0.16	0.14	0.13	0.09	0.08	0.0	0.32	0.34
133.33	11E6A27	Fraser Brook			3/3/68	2.5	1.5	2.9	0.02	0.0	4.1	6.1	0.0	0	3.6	12.4		27.0		43.0		6.4		20	1.0	0.13	0.12	0.13	0.19	0.07	0.0	0.36	0.36
133.34	11E6A27	Fraser Brook			10/3/68	2.0	1.6	2.7	0.04	0.1	7.2	3.9	0.0	0	4.8	11.6		23.7		44.8		6.4		15	1.0	0.10	0.13	0.12	0.15	0.11	0.0	0.35	0.35
133.35	11E6A27	Fraser Brook			23/3/68	1.8	0.9	1.9	0.10	0.05	8.1	2.9	0.0	0	2.5	10.0		19.6		29.2		6.4		30	1.0	0.09	0.07	0.08	0.17	0.08	0.0	0.36	0.29
133.36	11E6A27	Fraser Brook			25/3/68	2.0	1.0	2.2	0.03	0.10	4.0	3.7	0.0	0	2.7	9.1		17.2		33.3		6.4		20	1.0	0.10	0.08	0.10	0.08	0.10	0.0	0.36	0.32
133.37	11E6A27	Fraser Brook			30/3/68	1.7	0.9	1.8	0.08	0.10	4.2	3.1	0.0	0	2.4	5.9		15.4		27.6		6.1		40	3.0	0.09	0.07	0.08	0.09	0.09	0.0	0.36	0.28

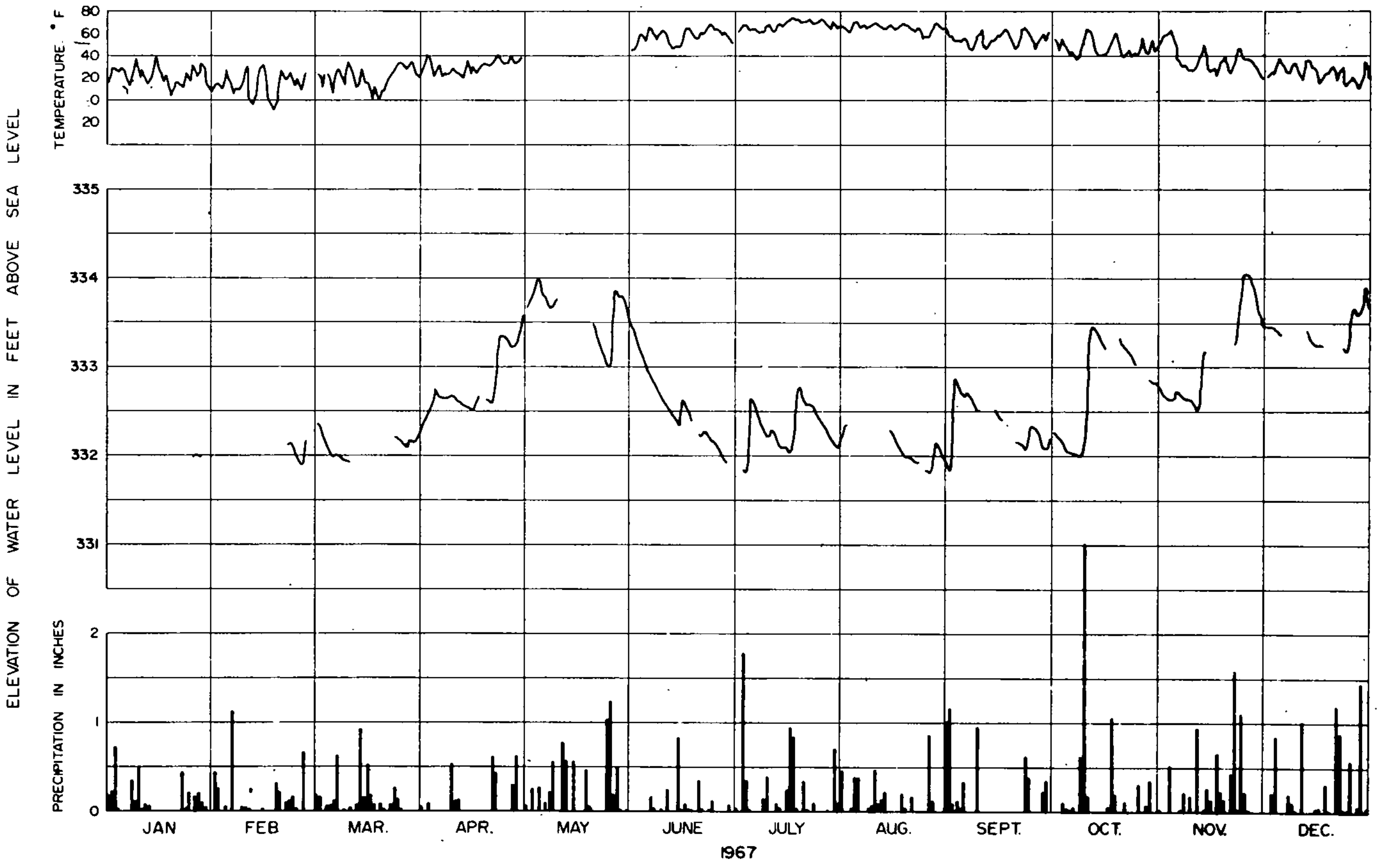
Appendix E. Contd.

Index No	Grid Location	Area	River Stage (ft)	River Flow (cfs)	Date Sampled	Analyses* in parts per million (ppm)																				Ions in equivalents per million (epm)							
														Alkalinities							pH					Cations			Anions				
						Ca	Mg	Na	Fe	Mn	SO_4	Cl	NO_3	Phenolphthalein as $CaCO_3$	Methyl Orange	Hardness	Ignition Loss	Total Dissolved Solids	Suspended Matter	Specific Conductance (mhos x 10^{-5})	Field	Lab	Field Temp °F	Colour	Turbidity	Ca	Mg	Na	SO_4	Cl	NO_3	SSP	SAR
133.38	11E6A27	Fraser Brook			1/4/68	1.7	0.8	2.0	0.14	0.05	5.4	3.0	0.0	0	2.3	7.6		16.6		26.5		6.0		30	1.0	0.09	0.07	0.09	0.11	0.09	0.0	0.39	0.32
133.39	11E6A27	Fraser Brook			14/4/68	1.8	0.6	3.0	0.23	0.10	4.8	3.0	0.0	0	4.5	6.9		18.3		32.7		7.0		30	12.0	0.09	0.05	0.13	0.10	0.09	0.0	0.50	0.49
133.40	11E6A27	Fraser Brook			20/4/68	2.0	1.1	2.6	0.11	0.0	5.6	2.8	0.1	0	4.7	9.6		19.3		32.8		6.3		30	2.0	0.10	0.09	0.11	0.12	0.08	0.002	0.39	0.37
133.41	11E6A27	Fraser Brook			27/4/68	1.9	0.7	2.4	0.13	1.01	6.0	2.8	0.1	0	4.0	7.7		18.2		32.4		6.2		40	2.0	0.10	0.06	0.10	0.13	0.08	0.002	0.43	0.38
133.42	11E6A27	Fraser Brook			12/5/68	2.3	1.3	2.5	0.09	0.0	5.4	3.3	0.0	0	6.5	11.1		20.8		36.6		6.3		30	0.2	0.12	0.11	0.11	0.11	0.09	0.0	0.34	0.33
133.43	11E6A27	Fraser Brook			20/5/68	2.3	1.3	2.4	0.11	0.05	5.8	2.8	0.10	0	6.6	11.1		20.8		34.4		6.9		40	0.2	0.12	0.11	0.10	0.12	0.08	0.002	0.33	0.31
133.44	11E6A27	Fraser Brook			16/6/68	2.5	1.4	2.3	0.15	0.0	3.5	2.5	0.0	0	9.3	2.0		0.0		37.6		6.8		45	0.38	0.13	0.12	0.10	0.07	0.07	0.0	0.31	0.29
133.45	11E6A27	Fraser Brook	0.91	3.4	25/6/68	2.5	1.4	2.3	0.16	0.0	3.5	2.1	0.0	0	10.0	12.0		0.0		38.2		7.0		40	0.70	0.13	0.12	0.10	0.07	0.06	0.0	0.31	0.29
133.46	11E6A27	Fraser Brook	0.23	0.11	2/7/68	3.0	1.6	2.7	0.13	0.0	4.4	2.2	0.0	0	11.4	14.0		0.0		41.4		6.9		40	0.40	0.15	0.13	0.12	0.09	0.06	0.0	0.31	0.31
133.47	11E6A27	Fraser Brook	0.51	0.80	7/7/68	4.0	1.2	3.0	0.14	0.0	3.6	2.6	0.0	0	15.0	15.0		0.0		49.7		7.0		20	0.30	0.20	0.10	0.13	0.08	0.07	0.0	0.32	0.34
133.48	11E6A27	Fraser Brook	0.70	1.80	6/7/68	0.8	0.4	2.6	0.37	0.02	2.6	3.8	0.0	0	0.0	3.7		0.0		25.1		4.0		50	0.30	0.04	0.03	0.11	0.05	0.11	0.0	0.62	0.59
133.49	11E6A27	Fraser Brook	0.43	0.32	22/7/68	4.7	1.5	2.6	7.2	0.0	3.9	2.9	0.0	0	27.3	18.8		0.0		63.2		7.4		15	0.20	0.24	0.12	0.11	0.08	0.08	0.0	0.25	0.27
133.50	11E6A27	Fraser Brook	0.18	0.06	30/7/68	6.2	1.5	3.4	0.0	0.0	5.3	4.3	0.0	0	19.9	21.9		0.0		62.7		7.4		10	0.30	0.31	0.12	0.15	0.11	0.12	0.0	0.26	0.32
133.51	11E6A27	Fraser Brook	0.24	0.12	18/8/68	6.4	1.3	3.5	0.07	0.0	4.5	2.7	0.02	0	19.7	27.2		0.0		59.6		7.2		10	0.20	0.32	0.11	0.15	0.09	0.08	0.0	0.28	0.33
133.52	11E6A27	Fraser Brook	1.84	31.80	25/8/68	5.6	0.21	2.3	0.28	0.23	11.8	2.4	0.08	0	3.8	15.3		0.0		48.2		6.1		40	3.50	0.28	0.02	0.10	0.25	0.07	0.001	0.28	0.26
133.53	11E6A27	Fraser Brook	0.24	0.12	18/8/68	6.4	1.3	3.5	0.07	0.0	4.5	2.7	0.02	0	19.7	21.2		0.0		59.6		7.2		10	0.20	0.32	0.11	0.15	0.09	0.08	0.0	0.28	0.33
133.54	11E6A27	Fraser Brook	1.84	31.80	25/8/68	5.6	0.21	2.30	0.28	0.23	11.8	2.4	0.10	0	3.8	15.3		0.0		48.2		6.1		40	3.5	0.28	0.02	0.10	0.25	0.07	0.002	0.28	0.26
133.55	11E6A27	Fraser Brook	0.43	0.52	2/9/68	7.8	0.50	3.40	0.19	0.0	8.8	2.9	0.0	0	15.9	21.5		0.0		64.0		7.1		10	0.28	0.39	0.04	0.16	0.18	0.08	0.0	0.28	0.34
133.56	11E6A27	Fraser Brook	0.33	0.27	8/9/68	6.6	1.70	3.40	0.21	0.0	8.8	2.7	0.0	0	18.0	23.5		0.0		63.2		7.3		10	0.14	0.33	0.14	0.16	0.18	0.08	0.0	0.26	0.32
133.57	11E6A27	Fraser Brook	0.22	0.10	22/9/68	7.8	1.60	3.70	0.12	0.05	5.0	2.9	0.0	0	20.7	23.2		0.0		65.7		7.3		10	0.35	0.39	0.13	0.16	0.10	0.08	0.0	0.24	0.32
133.58	11E6A27	Fraser Brook	0.55	0.97	29/9/68	8.3	0.40	3.40	0.24	0.05	8.1	4.1	0.0	0	15.2	22.4		0.0		67.6		7.0		20	0.35	0.41	0.03	0.15	0.17	0.12	0.0	0.26	0.31
133.59	11E6A27	Fraser Brook	0.58	1.10	6/10/68	5.2	2.40	3.40	0.20	0.0	13.4	4.6	0.0	0	12.0	22.8		0.0		85.0		7.0		40	1.40	0.26	0.20	0.15	0.28	0.13	0.0	0.27	0.31
133.60	11E6A27	Fraser Brook	0.35	0.31	14/10/68	7.2	2.00	3.60	0.10	0.0	12.7	3.7	0.0	0	17.0	27.2		0.0		69.5		6.8		10	1.10	0.36	0.16	0.16	0.26	0.10	0.0	0.24	0.31
133.61	11E6A27	Fraser Brook	0.66	1.5	4/11/68	6.7	0.60	3.10	0.23	0.05	7.8	4.8	0.0	0	10.4	19.5		0.0		59.9		6.9		20	0.88	0.33	0.05	0.14	0.16	0.14	0.0	0.27	0.31
133.62	11E6A27	Fraser Brook	1.02	4.7	18/11/68	4.3	0.70	2.70	0.24	0.05	7.3	4.0	0.10	0	3.3	13.5		0.0		42.7		6.5		30	1.50	0.22	0.06	0.12	0.15	0.11	0.002	0.31	0.32
133.63	11E6A27	Fraser Brook	1.69	23.6	25/11/68	4.1	0.30	2.20	0.34	0.07	6.4	4.4	0.10	0	2.9	11.4		0.0		38.1		6.2		40	2.80	0.21	0.03	0.10	0.13	0.12	0.002	0.31	0.28
133.64	11E6A27	Fraser Brook	1.71	24.5	17/12/68	2.8	0.30	1.70	0.25	0.02	5.0	3.4	0.0	0	2.1	8.4		0.0		29.3		6.2		30	0.54	0.14	0.03	0.07	0.10	0.10	0.0	0.33	0.26
133.65	11E6A27	Fraser Brook	1.42	13.0	30/12/68	3.3	0.40	2.10	0.19	0.02	5.3	3.8	0.07	0	3.0	9.9		0.0		34.4		6.2		20	0.65	0.17	0.03	0.09	0.11	0.11	0.001	0.32	0.29
133.66	11E6A27	Fraser Brook	1.01	4.5	12/1/69	3.0	0.60	1.90	0.19	0.08	5.3	3.3	0.01	0	4.0	10.0		0.0		35.8		6.3		15	0.58	0.15	0.05	0.08	0.11	0.09	0.0	0.31	0.26
133.67	11E6A27	Fraser Brook	1.24	8.2	19/1/69	4.3	0.30	2.00	0.18	0.05	8.8	3.4	0.22	0	2.4	11.9		0.0		38.3		6.1		15	1.20	0.22	0.03	0.09	0.18	0.10	0.004	0.28	0.25
133.68	11E6A27	Fraser Brook	1.17	6.8	28/1/69	3.6	0.40	1.90	0.18	0.0	6.3	3.6	0.18	0	3.3	10.7		0.0		35.8		6.5		20	0.44	0.18	0.03	0.08	0.13	0.10	0.003	0.30	0.25

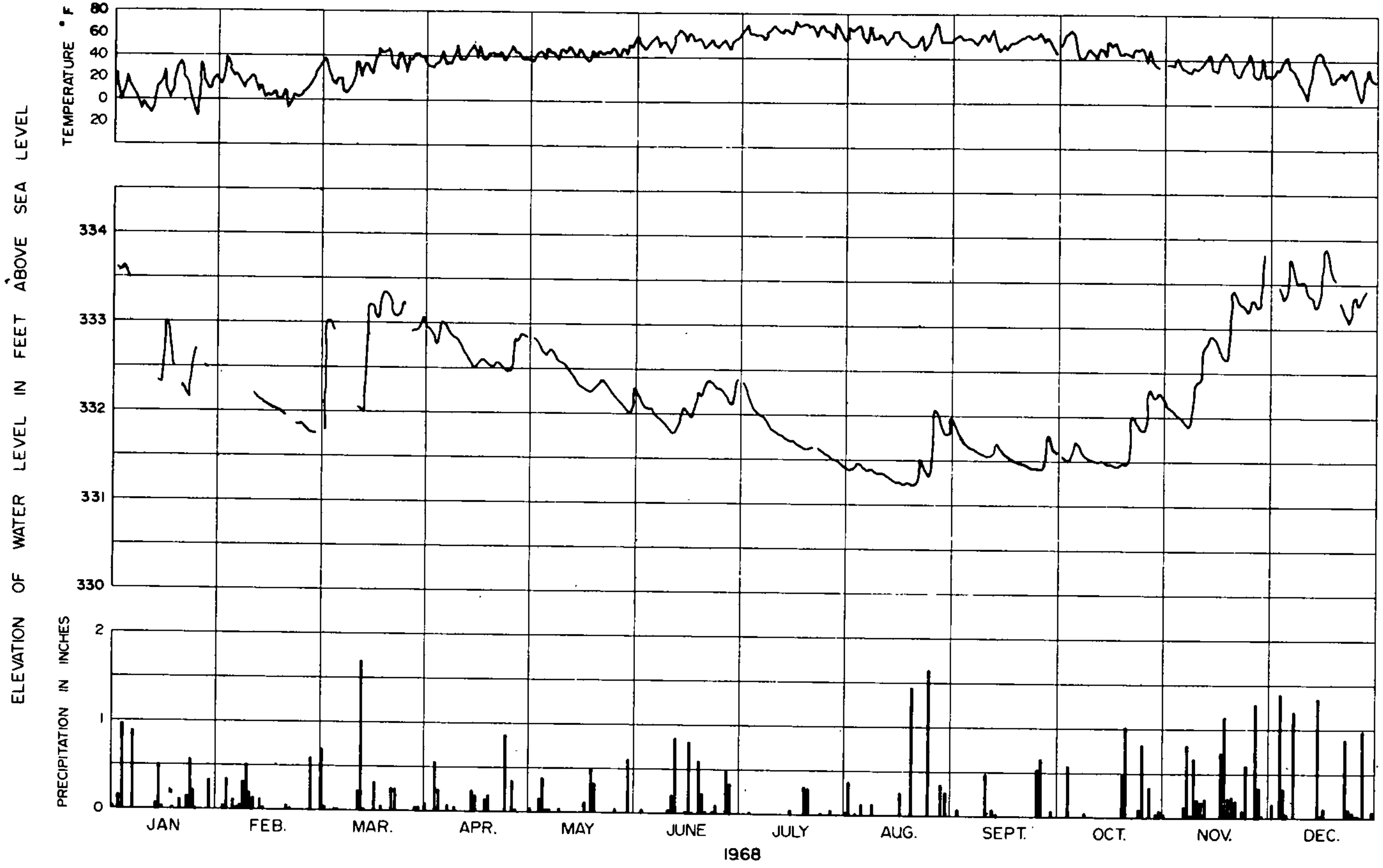
Index No	Grid Location	Area	River Stage (ft.)	River Flow (cfs)	Date Sampled	Analyses in parts per million (ppm)															pH		Field Temp °F	Colour	Turbidity	Ions in equivalents per million (epm)						SSP	SAR
														Alkalinities												Cations			Anions				
						Ca	Mg	Na	Fe	Mn	SO_4	Cl	NO_3	Phenolpthalein as $CaCO_3$	Methyl Orange	Hardness	Ignition Loss	Total Dissolved Solids	Suspended Matter	Specific Conductance (mhos × 10^{-5})	Field	Lab				Ca	Mg	Na	SO_4	Cl	NO_3		
133.69	11E6A27	Fraser Brook	1.21	7.5	2/2/69	3.4	0.60	1.90	0.14	0.05	6.6	3.4	0.11	0	3.9	10.9		0.0		35.1		6.7		20	1.20	0.17	0.05	0.08	0.14	0.10	0.002	0.29	0.25
133.70	11E6A27	Fraser Brook	1.04	5.0	9/2/69	3.3	0.60	1.70	0.13	0.03	6.0	3.4	0.22	0	5.0	10.9		0.0		35.9		6.4		15	0.61	0.17	0.05	0.07	0.13	0.10	0.004	0.27	0.23
133.71	11E6A27	Fraser Brook	1.07	5.4	16/2/69	3.1	0.80	1.90	0.13	0.04	6.2	3.0	0.16	0	4.3	11.0		0.0		33.5		6.4		15	0.57	0.16	0.07	0.08	0.13	0.09	0.003	0.29	0.25
133.72	11E6A27	Fraser Brook	0.92	3.5	23/2/69	3.7	0.50	3.60	0.11	0.02	4.6	7.4	0.24	0	5.1	11.3		0.0		36.5		6.5		15	0.62	0.19	0.04	0.16	0.10	0.21	0.004	0.42	0.47
133.73	11E6A27	Fraser Brook	0.61	1.3	9/3/69	4.5	0.40	2.30	0.16	0.05	6.4	2.8	0.31	0	8.5	12.8		0.0		45.1		6.9		5	1.70	0.23	0.03	0.10	0.13	0.08	0.005	0.29	0.28
133.74	11E6A27	Fraser Brook	1.34	0.29	23/3/69	3.7	0.50	2.10	0.16	0.06	5.0	4.8	0.39	0	3.8	11.3		0.0		38.5		6.3		20	1.60	0.19	0.04	0.09	0.10	0.14	0.006	0.32	0.27
133.75	11E6A27	Fraser Brook	0.92	3.5	23/2/69	3.7	0.50	3.60	0.11	0.02	4.6	7.4	0.24	0	5.1	11.3		0.0		36.5		6.5		15	0.42	0.19	0.04	0.16	0.10	0.21	0.004	0.42	0.47
133.76	11E6A27	Fraser Brook	1.34	10.6	23/3/69	3.7	0.50	2.10	0.16	0.06	5.0	4.8	0.39	0	3.8	11.3		0.0		38.5		6.3		20	1.60	0.19	0.04	0.09	0.10	0.14	0.006	0.32	0.27
133.77	11E6A27	Fraser Brook	1.70	24.0	30/3/69	1.5	0.90	1.40	0.09	0.02	3.6	3.8	0.0	0	2.1	7.5		0.0		30.7		6.2		20	2.30	0.08	0.07	0.07	0.08	0.11	0.0	0.34	0.26
133.78	11E6A27	Fraser Brook	0.59	1.2	19/3/69	4.9	0.70	2.90	0.14	0.0	5.6	3.5	0.46	0	9.6	15.2		0.0		46.2		6.7		10	0.72	0.25	0.06	0.13	0.12	0.10	0.007	0.31	0.32
133.79	11E6A27	Fraser Brook	1.17	24.5	6/5/69	3.3	0.70	2.20	0.12	0.02	6.2	2.9	0.0	0	4.8	7.2		0.0		36.0		6.5		25	0.92	0.17	0.06	0.10	0.13	0.08	0.0	0.32	0.29
133.80	11E6A27	Fraser Brook	1.06	5.3	5/8/69	2.5	2.00	2.80	0.04	0.01	6.3	3.3	0.02	0	9.7	14.5		0.0		48.0		6.4		30	0.80	0.13	0.16	0.12	0.13	0.09	0.0	0.31	0.32
133.81	11E6A27	Fraser Brook	0.65	1.5	2/6/69	2.6	1.60	2.80	0.07	0.02	5.70	3.2	0.05	0	9.8	14.2		0.0		41.8		6.8		20	0.74	0.13	0.13	0.12	0.12	0.09	0.001	0.34	0.34
133.82	11E6A27	Fraser Brook			2/6/70	3.6	2.20	3.00	0.07	0.01	6.20	4.1	0.83	0	10.7	18.1		0.0		48.7		6.6		10	0.80	0.18	0.18	0.13	0.13	0.12	0.01	0.27	0.31
133.83	11E6A27	Fraser Brook			2/3/70	3.2	2.10	3.20	0.08	0.0	5.60	4.2	0.75	0	10.7	16.6		0.0		49.8		6.9		10	1.50	0.16	0.17	0.14	0.12	0.12	0.01	0.31	0.34
133.84	11E6A27	Fraser Brook	1.53	16.8	5/4/70	2.1	1.10	2.10	0.08	0.05	5.90	3.90	0.24	0	3.9	9.8		0.0		34.9		6.4		15	2.70	0.11	0.09	0.09	0.12	0.11	0.004	0.35	0.29
133.85	11E6A27	Fraser Brook			5/1/70	2.9	1.50	2.60	0.09	0.01	5.60	4.20	0.19	0	7.4	13.4		0.0		44.0		6.7		10	0.80	0.15	0.12	0.11	0.12	0.12	0.003	0.31	0.31

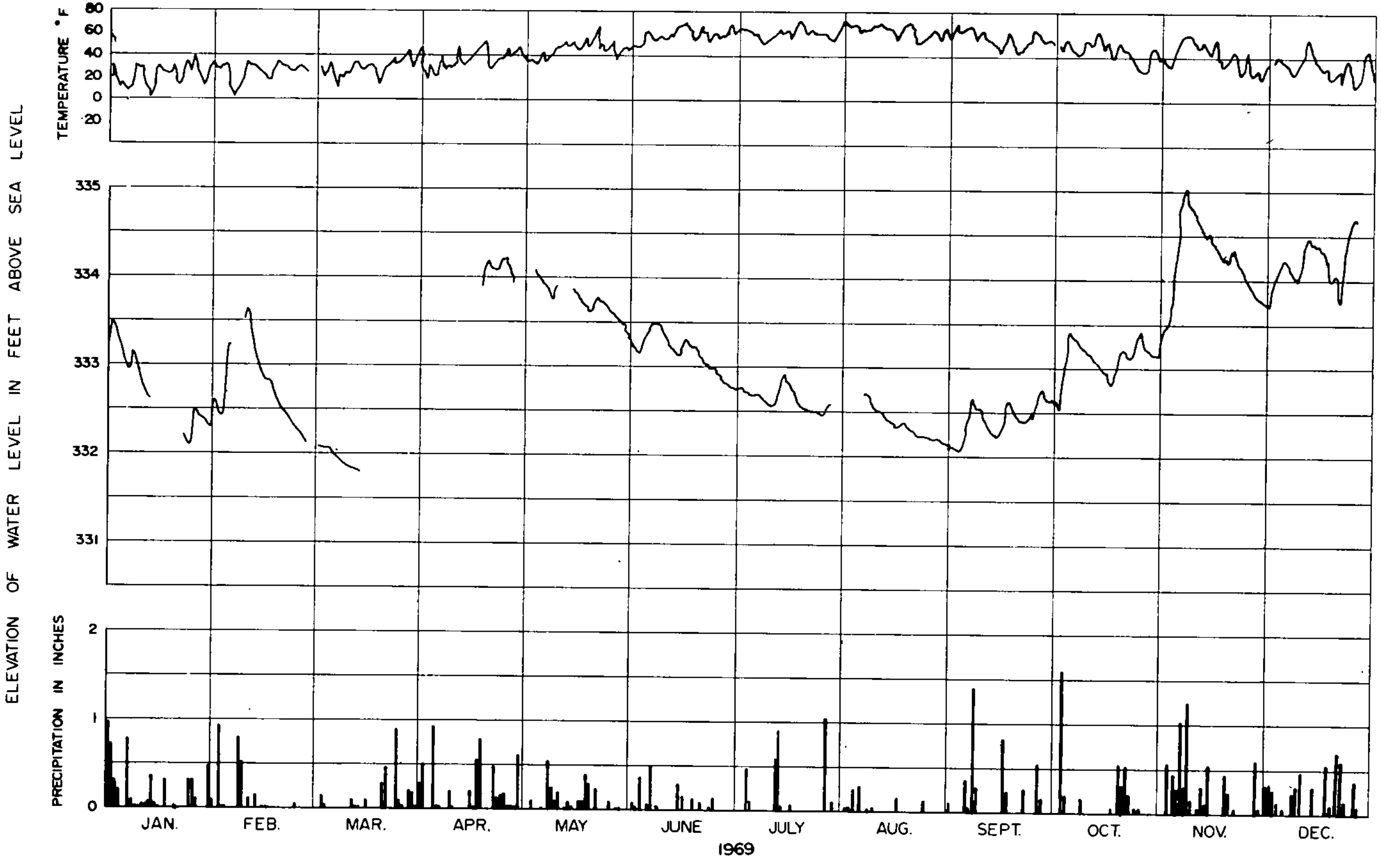
Appendix F. Groundwater hydrographs from the Canso Group at Fraser Brook for 1966 - 1969.



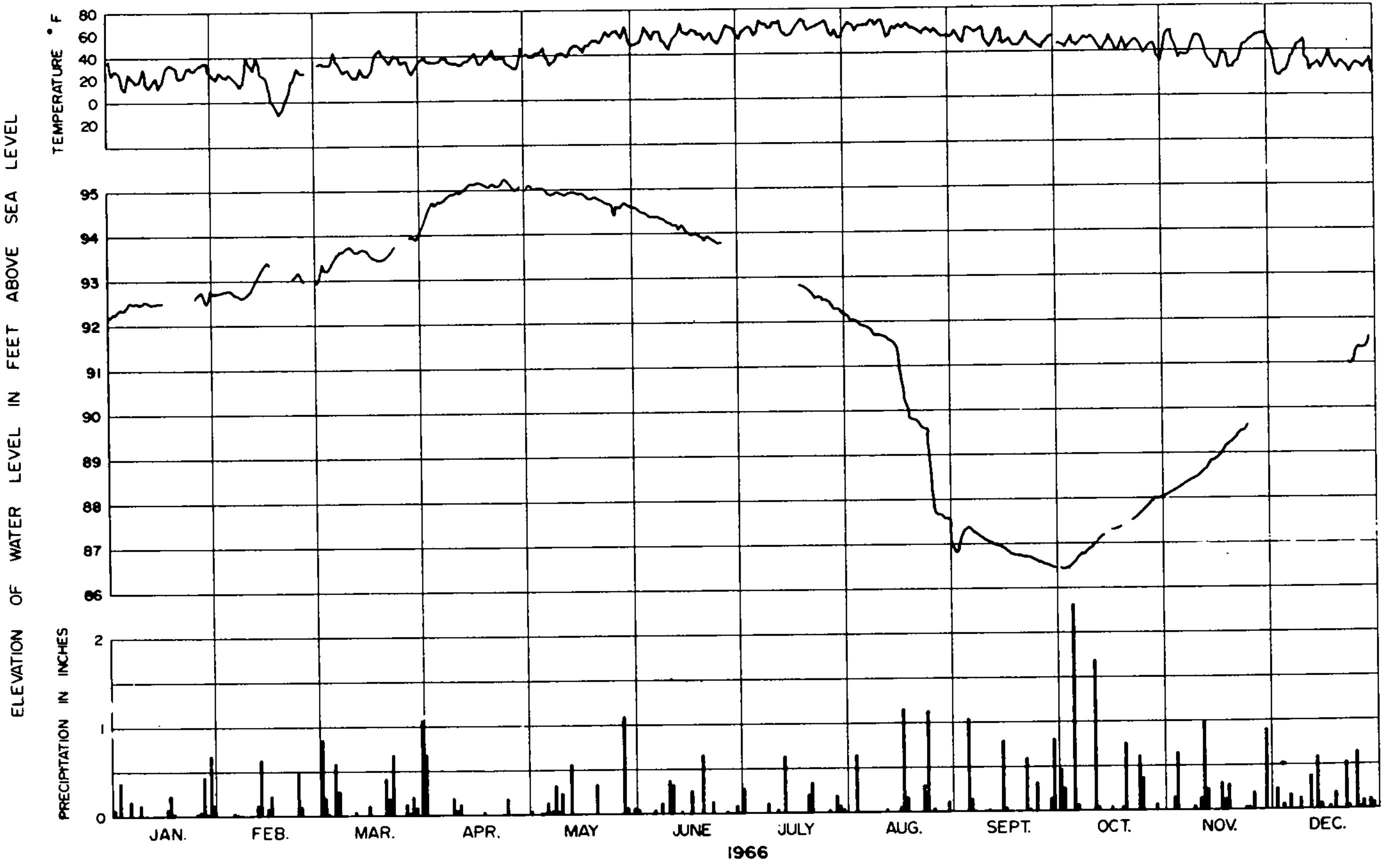

ELEVATION OF WATER LEVEL IN FEET ABOVE SEA LEVEL
TEMPERATURE °F
80
60
40
20
0
20
335
334
333
332
331
PRECIPITATION IN INCHES
2
1
0
JAN
FEB
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
1967

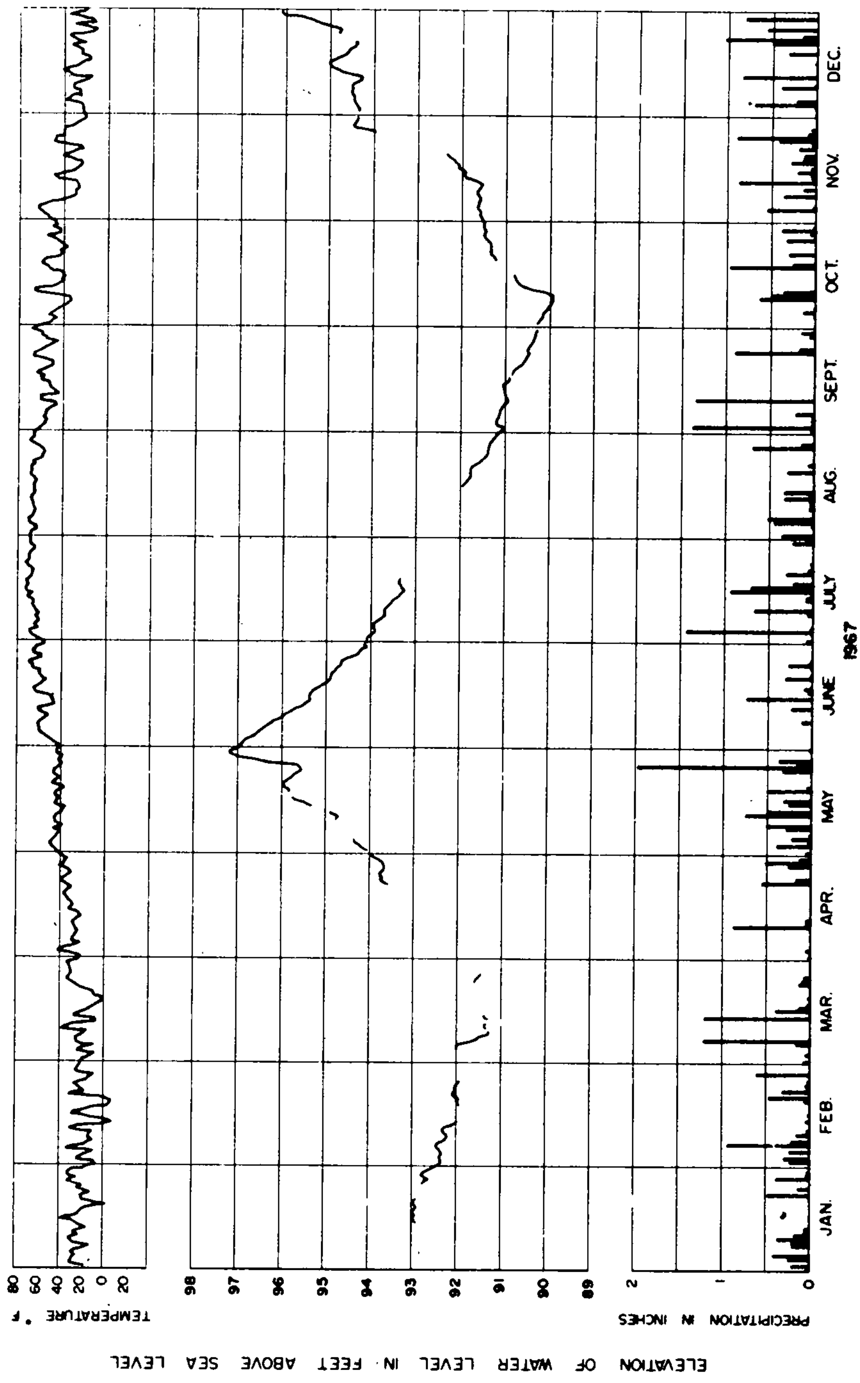
Appendix F. Contd.




ELEVATION OF WATER LEVEL IN FEET ABOVE SEA LEVEL
TEMPERATURE °F
80
60
40
20
0
-20
335
334
333
332
331
PRECIPITATION IN INCHES
2
1
0
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
1969

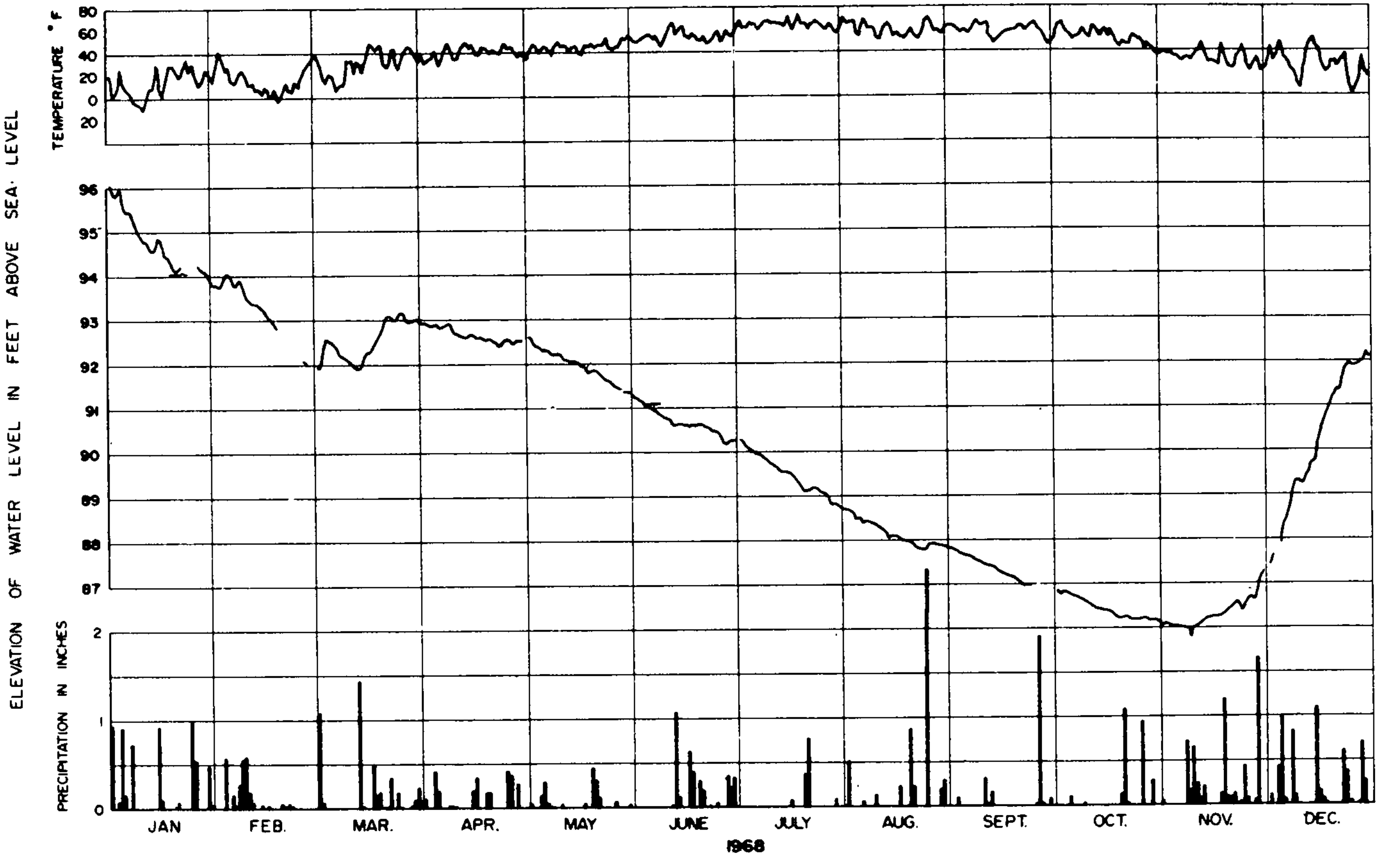
Appendix G. Groundwater hydrographs from the Wolfville Formation at Bible Hill from 1966 - 1969.

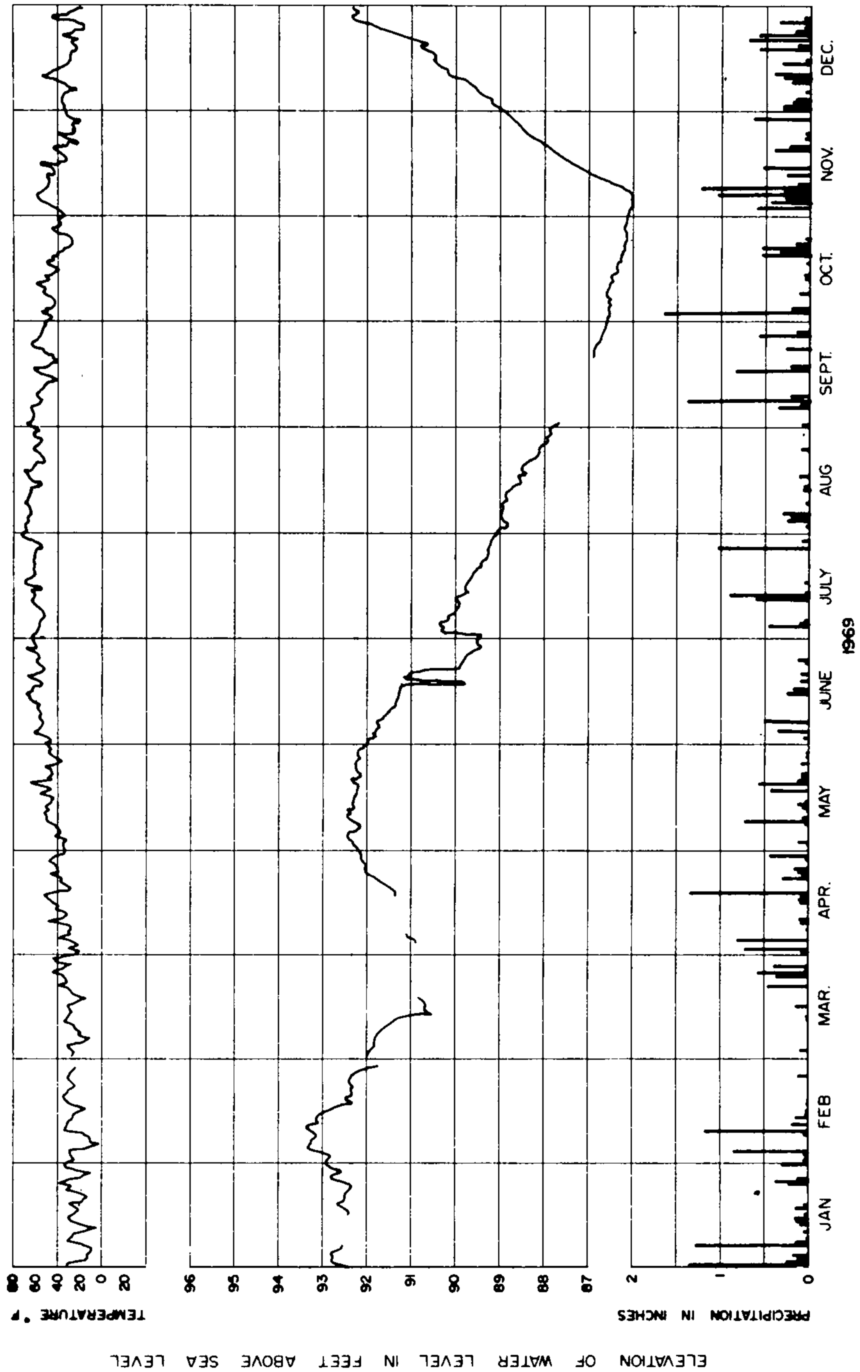




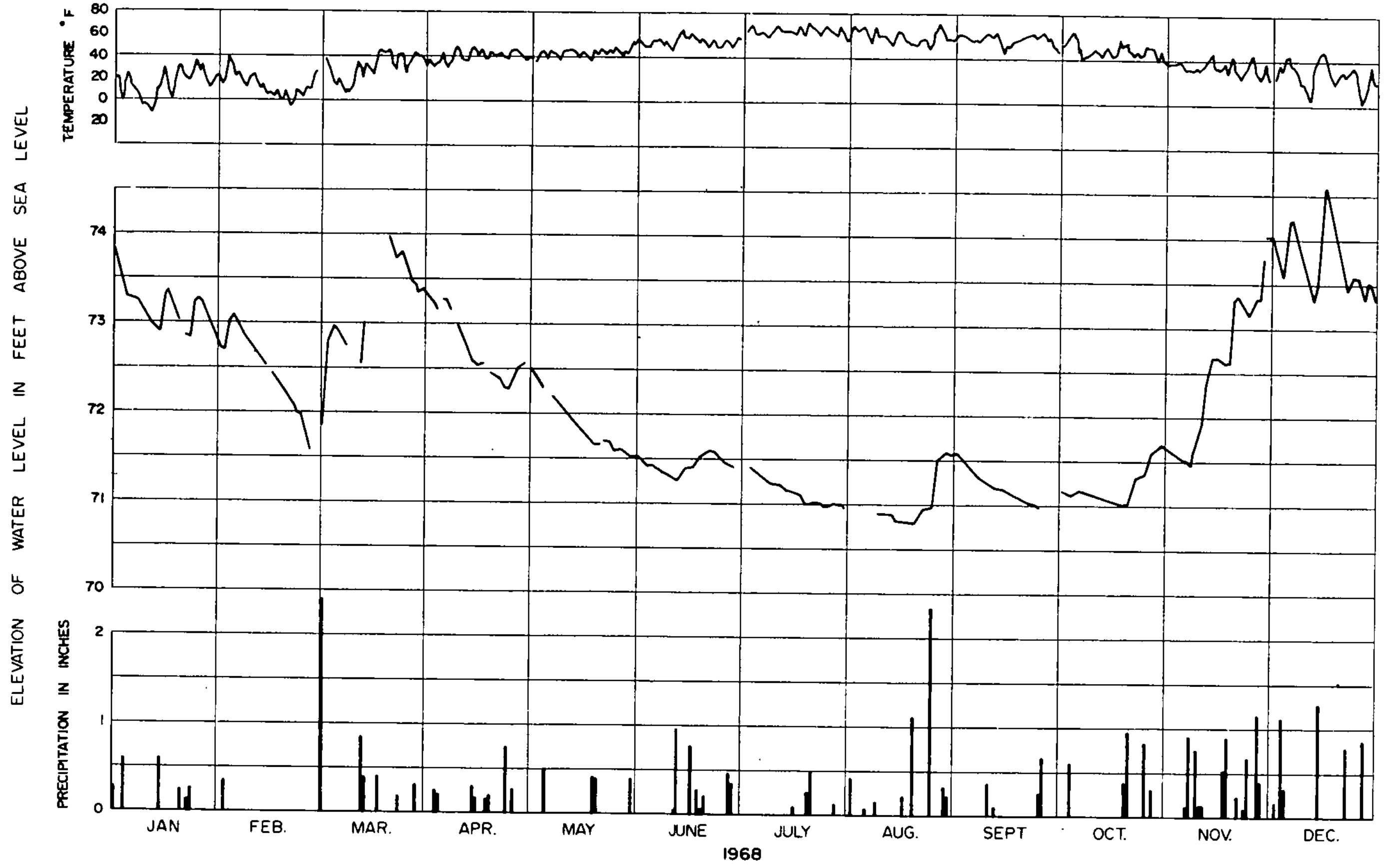
TEMPERATURE °F
80
60
40
20
0
20
ELEVATION OF WATER LEVEL IN FEET ABOVE SEA LEVEL
98
97
96
95
94
93
92
91
90
89
PRECIPITATION IN INCHES
2
1
0
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
1967

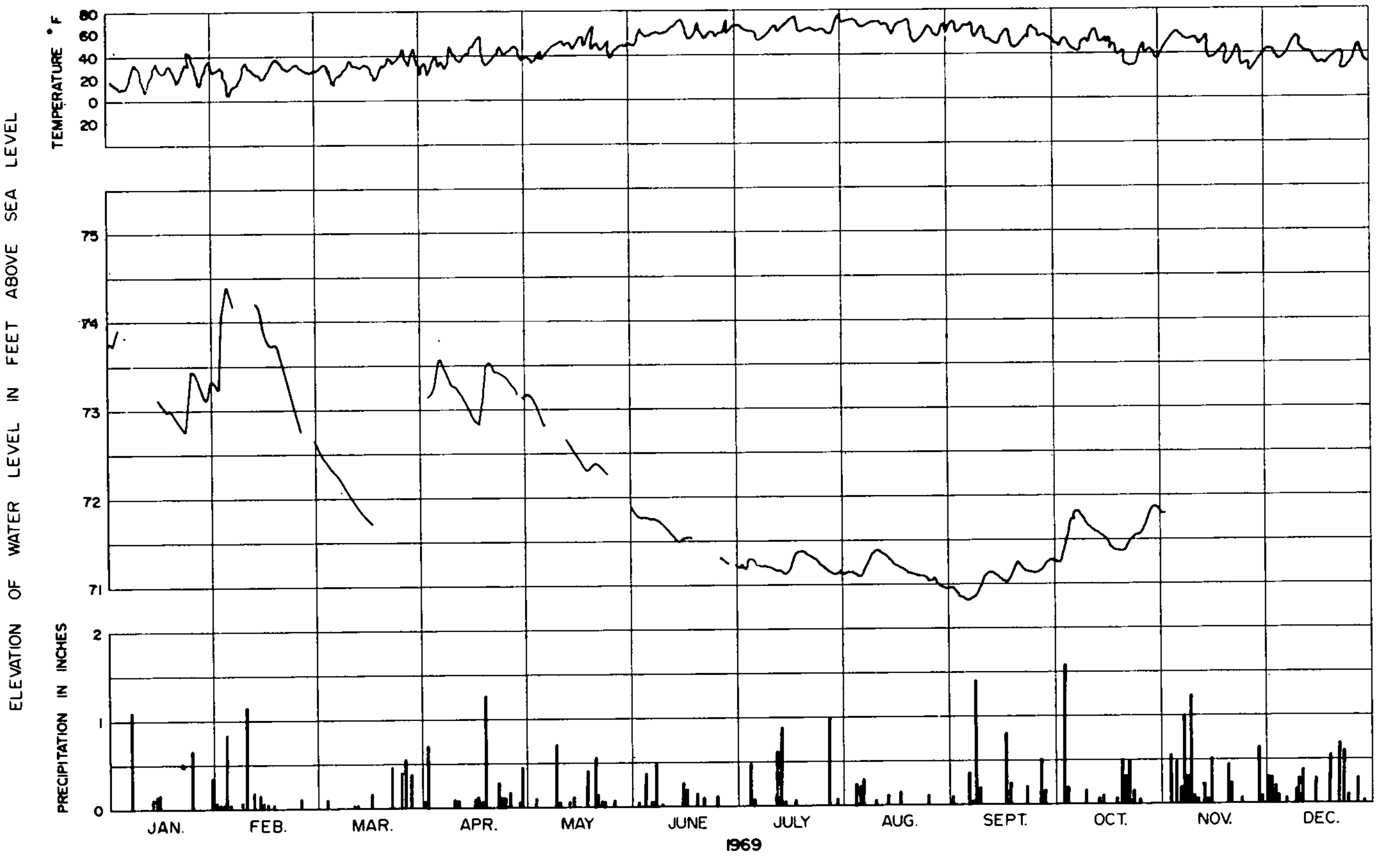
Appendix G. Contd.




TEMPERATURE °F
80
60
40
20
0
20
ELEVATION OF WATER LEVEL IN FEET ABOVE SEA LEVEL
96
95
94
93
92
91
90
89
88
87
PRECIPITATION IN INCHES
2
1
0
JAN
FEB
MAR
APR.
MAY
JUNE
JULY
AUG
SEPT.
OCT.
NOV.
DEC.
1969

Appendix H. Groundwater hydrographs from the glaciofluvial deposits at Murray for 1968 and 1969.




TEMPERATURE °F
80
60
40
20
0
20
ELEVATION OF WATER LEVEL IN FEET ABOVE SEA LEVEL
75
74
73
72
71
PRECIPITATION IN INCHES
2
1
0
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
1969

ADDENDUM TO REFERENCES

NOVA SCOTIA DEPARTMENT OF MINES

Groundwater Section Report 72-1

Brandon, L.V., 1966, Groundwater Probability Truro (West Half), Map 1160A: G.S.C.

Cruff, R.W. and Thompson, T.H., 1967, A Comparison of Methods of Estimating Potential Evapotranspiration from Climatological Data in Arid and Sub-humid Environments: U.S.Geol. Surv. Water Supply Paper 1839-M, 28p.

Dawson, J.W., 1893, The Canadian Ice Age, being notes on the Pleistocene geology of Canada, with special reference to the life of the period and its climatic conditions, privately published, Montreal, 301 p.

DeWiest, Roger, J.M., 1967, Geohydrology: John Wiley and Sons Inc., New York, 366 p.

Ferris, J.G., Knowles, D.B., Brown, R.H. and R.W.Stallman, 1962, Theory of Aquifer Tests: U.S.Geol. Surv. Water Supply Paper 1536-E, 106 p.

Freeze, R.A., 1967, Potev in Computer Programmes in use by the Hydrologic Sciences Division, Inland Waters Branch, Department of Energy, Mines and Resources.

Hem, J.D., 1959, Study and Interpretation of the Chemical Characteristics of Natural Waters: U.S.Geol. Surv. Water Supply Paper 1473, 269 p.

Hennigar, T.W., 1968, Hydrology of the Salmon River and Adjacent Watersheds, Colchester Co., Nova Scotia: M.Sc. Thesis, Dalhousie University, 192 p.

Holmes, R.M. and Robertson, G.W., 1960, Application of the Relationship between Actual and Potential Evapotranspiration in Arid Zone Agriculture: Paper No. 60-200, Ann. Mtg., Am. Soc. Agr. Engrs.

Krynine, P.D., 1948, The megascopic and Field Classification of Sedimentary Rocks: Journ. Geol., Vol. 56.

Leopold, Luna B., and Walter B.Langbein, 1960, A Primer on Water: U.S.Dept. of the Interior and the U.S.Geol. Surv., 50 p.

ADDENDUM TO REFERENCES
Nova Scotia Department of Mines
Groundwater Section Report 72-1

Meinzer, O.E., and Norah B. Stearns, 1929, A study of Groundwater in the Pomperauq Basin, Connecticut, with Special Reference to Intake and Discharge: U.S.Geol. Surv. Water Supply Paper, 597-B.

Powers, S., 1916, The Acadian Triassic: Jour. Geol., v. 24, p. 1-26, 105-122, 254-268.

Swenson, H.A., and H.L. Baldwin, 1965, A Primer on Water Quality: U.S. Geol. Surv., 27 p.

Wilccx, L.V., (1955), Classification and Use of Irrigation Waters: U.S.Dept. of Agr. Circ. 969, 19 p.